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IDENTIFIERS

ABSTRACT

Twelve PLATO lessons are reproduced in this document to show the status of computer guided experimentation (CGE) instructional programs. The lesson topics include a description of the CGE-PLATO instructional laboratory, an introduction to CGE-PLATO tests and special software routines, router lesson for two electrical engineering courses, and an introduction to the CGE station. Lesson five is the operation and uses of the oscilloscope Analab 1120, and lesson six concerns the operation and uses of the audio oscillator, HP 200AB. Lessons seven, eight, and nine introduce the operation and use of the function generator Exact 251; the D.C. supply, Harrison 865B; and the vacuum tube voltmeter, HP400D. Lesson ten is an experiment in the measurement of transients, lesson eleven is an experiment in measurements of impedance, and lesson twelve is an experiment in measurement of two-port networks. (CH)

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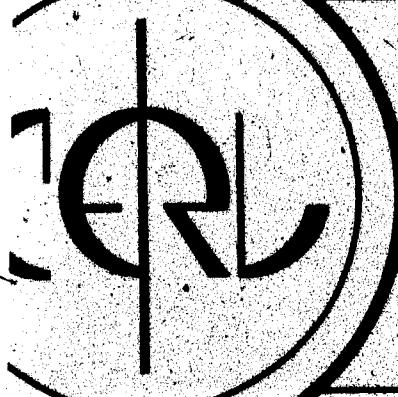
**THE CGE—PLATO
ELECTRONIC LABORATORY
INSTRUCTIONAL PROGRAMS**

U.S. DEPARTMENT OF HEALTH,
EDUCATION & WELFARE
NATIONAL INSTITUTE OF
EDUCATION

J.P. Neal

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THE CGE-PLATO ELECTRONIC LABORATORY
INSTRUCTIONAL PROGRAMS

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ABSTRACT

The twelve PLATO Lessons reproduced as Varian Prints in this report show the status of the CGE Instructional Programs as of August, 1974. This MTC Report supplements MTC Report #4, "The CGE-PLATO Electronic Laboratory Station Structure and Operation," and MTC Report #5, "Electronic Laboratory Instruction Using the CGE-PLATO Laboratory Station."

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TABLE OF CONTENTS
and
TAB LESSON-LOCATOR

PLATO Lesson cge'

PLATO Lesson cgerl

PLATO Lesson cgeindex

PLATO Lesson eex00

PLATO Lesson eex01

PLATO Lesson eex02

PLATO Lesson eex03

PLATO Lesson eex04

PLATO Lesson eex05

PLATO Lesson eex06

PLATO Lesson eex07

PLATO Lesson eex08

----- part=1, block=a -----

block 1a, cgeid

2 stop
 3 **** For Neal, CGERL, Room 248 EEB.

4 One line description of this lesson --

5 A Description of the CGE-PLATO Instructional Laboratory.

6 Divisions of this Lesson:

7 Log of users of this lesson
 8 Description of cge
 9 Recent userlog
 10 Common for log of users of cge

Block	Unit
cgeid	cgeida
cgemfa	cgemfa
userlog	
uselog	

11 Final edit 26 aug 74 neal.

12 *list info
 13 *list symbols
 14 *list varian,charset,cgeindex,cgechar
 15 *****
 16 start
 17 ext 0
 18 dataon
 19 area cge
 20 course n70
 21 jump n70='eecge',cgemfa,x
 22 ***

23 unit cgeida \$\$ logs all noncge users into uselog.
 24 common cge,uselog,322
 25 jump nc2:315,cgemfa,x
 26 values nc1=cgedata',nc1+'cgedata','cgedata'+0(nc2+4)
 27 name nc(nc2)
 28 calc nc(nc2)+nc(nc2)+055
 29 calc nc(nc2+nc2+1)+n70+055
 30 date nc(nc2+nc2+1)
 31 calc nc(nc2+nc2+1)+(int(station+32)+27)810
 32 calc nc(nc2+nc2+1)+nc(nc2+nc2+1)+(frac(int(station/32)*10+27))8⁸
 33 calc nc(nc2+nc2+1)+nc(nc2+nc2+1)+10468⁶
 34 calc nc(nc2)+nc(nc2)+(int(frac(v3+station+32)*3,2)+27)8⁴
 35 calc nc(nc2)+nc(nc2)+(frac((frac(v3+station+32)*3,2))*10+27)8²+055
 36 nb2+nc2+2
 37 jump cgemfa
 38 ***

39 unit cgeids \$\$ provides jumpout to sample
 40 term sample
 41 at 1617
 42 write One moment please..... returning to SAMPLE.

43 inhibit.jumpchk
44 jumpout sample
45 next .cge1db

----- part-1, block-b -----

block 1b, cgemfa

47 unit cgemfa
48 base
49 next cgemfb
50 at 205
51 write A Description of the CGE-PLATO Instructional Laboratory
52 in CGERL, Room 248 EEB, University of Illinois

53 As outlined herein, Computer-Guided Experimentation,
54 CGE instructional experiments are designed for use at
55 a special CGE-PLATO laboratory station which has a CGE
56 hardware interface linking sensors on adjacent electronic
57 laboratory equipment with the PLATO console.

58 For an operational demonstration of CGE, contact:

59 Dr. J. P. Neal, Prof. Emeritus
60 Department of Electrical Engineering
61 University of Illinois,
62 Urbana, Illinois 61801

63 217-333-4351 or 333-3496 or 344-6116

64 Or come visit the CGE Research Laboratory (GERL) at:

65 Room 248 EEB, University of Illinois, Urbana, Ill.

66 Press -NEXT- to proceed.

----- part-1, block-c -----

block 1c, cgemfb

68 unit cgemfb
69 back cgemfa
70 next cgemfc
71 at 804
72 write The object of this CGE-PLATO research is to demonstrate
73 that the Computer-Guided Experimentation-PLATO system will
74 provide unique and worthwhile improvements in undergraduate
75 or technician laboratory instruction, when properly used

76 by competent instructors.

77 The CGE station consists of a PLATO IV console, a
78 CGE-PLATO Interface Logic System, five rack-mounted
79 electronic instruments, and various experimentation
80 circuit boards for student use in learning electronic
81 instrumentation and measurements.

82 Students presently active in CGE Research are:

83 Borth, David E.
84 Derrig, Daniel P.
85 Zanter, Douglas L.

86 ***

87 unit cgem0c
88 back cgem0b
89 next cgem0d
90 at 504

91 write The CGE-PLATO Interface Logic System enables any author
92 to order the automatic sensing of the interconnections
93 between 30 terminals on the rack-mounted equipment or on
94 the currently-used circuit board and/or the settings of
95 22 of the dials, knobs, or switches on the equipment.

96 The panel layout of the present CGE station is
97 illustrated in the next display. The present CGE
98 rack-mounted instruments are:

99 Analab Dual-trace Scope Type 1120 and Plug-In Type 700
100 Exact Function Generator Type 251
101 Hewlett-Packard Audio Oscillator Model 200AB
102 HP Vacuum Tube Voltmeter Model 4000
103 Harrison Lab. Model 865B Power Supply.

104 The CGE-PLATO Interface Logic System is mounted behind
105 the instrument rack panel, beneath the Function Generator.

106 On the next display, the automatically-sensed terminals
107 may be identified by T numbers, and the automatically-
108 sensed dials may be identified by D numbers.

----- part=1, block=d -----

block 1d, jcgem0d

110 unit cgem0d
111 back cgem0c
112 define panel
113 switch=1
114 trmnl=2
115 ground=3
116 dcsw=4
117 solid=5

118 char trmml
119 . o000016, o000033, o000021, o000033, o000016, o000000, o000000, o000000
120 char switch
121 . o000000, o000340, o000760, o001777, o001777, o000760, o000340, o000000
122 char ground
123 . o000000, o100000, o120000, o124000, o124000, o120000, o180000, o000000
124 char dcsw
125 . o000600, o000600, o000600, o000600, o001700, o003740, o003740, o001700
126 char solid
127 . o177777, o177777, o177777, o177777, o177777, o177777, o177777
128 draw 509, 133; 0, 133
129 zero n5
130 zero n6
131 calc n7#1314
132 join cgesla
133 join cgeslb
134 add1 n5
135 calc n7#1534
136 join cgesla
137 join cgeslc
138 add1 n5
139 calc n7#1552
140 join cgesla
141 join cgesld
142 add1 n5
143 calc n7#2212
144 join cgesla
145 join cgesle
146 add1 n5
147 calc n7#2243
148 join cgesla
149 join cgeslf
150 add1 n5
151 join cgesla
152 join cgeslg
153 at 3117
154 write Press -LAB- for sensed dials.
155 . Press -DATA- for sensed terminals.
156 entry cgem@de
157 pause
158 calc n1#(key=next\$or\$key=back) - (key=lab) - 2 (key=data)
159 join n1, x, x, cges2a, cges3a, x
160 jump /key=next) - (key=back), cgem@de, x, cgem@c
161 goto key=o216, x, cgem@de, x
162 press o216
163 ***

----- part=1, block=e -----

block ie, cgem@e

165 unit cgem@e
166 back cgem@d

167 next cgemff
168 at 705

Actual laboratory experiments are programmed by experienced laboratory instructors on the PLATO system.

171 The instructor writing a program provides for the
172 automatic sensing of terminal interconnections and/or
173 dial settings wherever he deems necessary.

174 The response of the program to the feedback information
175 of the student's physical operations can be used in any
176 manner the instructor devises for improving the student's
177 learning.

178 Each student can work independently at a CGE station
179 and learn at his own rate how to use the equipment,
180 and perform or devise meaningful experiments.

181 ***

182 unit cgemff

183 back cgemfe

184 next cgemfg

185 at 903

186 write CGE is an entirely new instructional system, and
187 research is required to develop its teaching capabilities
188 and demonstrate their superiorities in comparison with
189 conventional laboratory instruction or training simulators.

190 CGE is not simply a new Teaching Aid, it is a New Teaching
191 Method with unexplored and unknown capabilities.

192 The manner in which a student at a CGE station in a
193 laboratory is provided ready access to laboratory facilities,
194 theoretical material, computer assistance, and
195 instructor assistance is visualized in the next display.

----- part=1, block=f -----

block 1f. cgemff

197 unit cgemfg

198 back cgemff

199 next cgemfh

200 calc n1#.5

201 circle 129,256,368

202 at 427

203 write Student

in

205 Laboratory

206 delay n1

207 circle 129,256,144

208 at 2626

209 write Student
210 in
211 Theory Course
212 delay n1
213 circle 128,320,256
214 at 1746
215 write Instructor
216 delay n1-2
217 at 2238
218 write Instructor
219 Aid
220 at 1038
221 write Instructor
222 Aid
223 delay n1
224 circle 128,192,256
225 at 1711
226 write Computer
227 delay n1-2
228 at 2219
229 write Computer
230 Aid
231 at 1019
232 write Computer
233 Aid
234 delay n1+2
235 at 244,192
236 write CAI
237 delay n1+2
238 at 244,304
239 write CGE
240 delay n1+2
241 size 1
242 at 212,249
243 write CGE Station
244 delay n1-2
245 size 8
246 mode rewrite
247 at 3087
248 write The CGE Station provides the student with complete
249 access to Computer Aid and Instructor Aid for both lab-
250 oratory and theoretical learning.
251 mode write

----- part=1, block=g -----

block 1g, cgem0h

253 unit cgem0h
254 back cgem0g
255 next cgem0f
256 at 204
257 write All the PLATO lessons used by CGE are open for inspection
258 by authors. These lessons are:

259 CGE-PLATO
260 LESSON

TOPIC

261 cge A Description of the CGE-PLATO Instructional Lab.
262 cgerl CGE-PLATO Tests & Special Software Routines
263 ee244 Student List for CGEPL Course
264 eecge Author List for CGERL Course
265 cgeindex Router Lesson for Courses ee244 and eecge
266 cgedata Data File for Courses ee244 and eecge
267 eex00 An Introduction to the CGE Station
268 eex01 The Oscilloscope
269 eex02 The Audio Oscillator
270 eex03 The Function Generator
271 eex04 The Constant Voltage/Constant Current Supply
272 eex05 The Vacuum Tube Voltmeter
273 eex06 Measurements of Transients
274 eex07 Measurements of Impedance
275 eex08 Measurements of Two-Port Networks

276 Note: Authors in the student mode can press -MICRO-
277 to pass OK through a check. Students cannot do this.

278 MTC Report #4, July 1974, CERL, is entitled
279 "The CGE-PLATO Electronic Laboratory Station Structure
280 and Operation", by J. P. Neal.

281 ***

282 unit cgem01
283 back cgem0b
284 next cgeend
285 at 707
286 write To review this Description of CGE-PLATO, press -BACK-.

287 To access the CGE Experiments, press -NEXT-.

----- part=1, block=h -----

block 1h, cgesia

289 unit cgesia
290 at n6
291 mode erase
292 writec n5-1, Dual-Trace SCOPE, Audio Oscillator, VTVM,
293 Function Generator, DC Supply,,
294 calc n6+n7
295 at n7
296 mode write
297 writec n5, Dual-Trace SCOPE, Audio Oscillator, VTVM,
298 Function Generator, DC Supply,,
299 ***

300 unit cgesib

301 draw 606;635;1235;1206;606
302 circle 35,103,369
303 circle 3,55,366
304 circle 6,55,396
305 circle 6,55,336
306 circle 6,149,336
307 at 146,368
308 plot switch
309 at 165,327
310 plot trmm1
311 at 165,335
312 plot trmm1
313 at 179,327
314 plot trmm1
315 at 191,327
316 plot trmm1
317 at 260,327
318 plot trmm1
319 at 248,327
320 plot trmm1
321 at 236,327
322 plot trmm1
323 at 260,335
324 plot trmm1
325 circle 6,149,396
326 circle 3,181,392
327 circle 10,181,392
328 circle 3,213,392
329 circle 10,213,392
330 circle 3,245,392
331 circle 10,245,392
332 circle 6,255,352
333 circle 6,227,352
334 circle 6,199,352
335 circle 6,171,352
336 ***

337 unit cgesic
338 draw 637;647;1447;1437;637
339 circle 13,328,368
340 circle 35,328,368
341 circle 5,328,329
342 circle 10,353,311
343 circle 10,304,311
344 at 327,294
345 plot trmm1
346 at 337,294
347 plot trmm1
348 at 317,294
349 plot trmm1
350 at 358,400
351 plot switch
352 ***

353 unit cgesid
354 draw 649;659;1459;1449;649;skip;394,404;453,404;453,364;394,364;394,404
355 circle 44,424,334,135,46

356 draw 419,377;488,396
357 circle 13,424,327
358 at 452,339
359 plot switch
360 at 452,309
361 plot trmn1
362 at 452,295
363 plot trmn1
364 at 393,295
365 plot trmn1
366 at 393,309
367 plot trmn1
368 ***

369 unit gesie
370 draw 1606;1635;2185;2186;1686
371 circle 8,160,217
372 circle 25,160,217
373 circle 4,184,199
374 circle 10,224,227
375 circle 6,224,227
376 at 256,245
377 plot trmn1
378 at 256,235
379 plot trmn1
380 at 256,225
381 plot trmn1
382 at 256,215
383 plot trmn1
384 at 256,185
385 plot trmn1
386 at 240,185
387 plot trmn1
388 at 222,185
389 plot trmn1
390 circle 5,201,185
391 circle 8,115,230
392 circle 8,83,230
393 at 51,237
394 plot trmn1
395 at 51,227
396 plot trmn1
397 at 51,217
398 plot trmn1
399 at 88,188
400 plot switch
401 ***

402 unit gesif
403 draw 2141;1841;1853;2153;2141
404 draw 357,218;325;218;325,194;357,194;357,218
405 circle 6,401,194
406 circle 6,401,213
407 circle 6,376,203
408 at 393,181
409 plot trmn1
410 at 381,181

```
411 plot trmn1  
412 at 369,181  
413 plot trmn1  
414 at 329,177  
415 plot dcsw
```

----- part=i, block=i -----

block ii, cgesig

```
417 unit cgesig  
418 at 2810  
419 write Location behind the panel of the complete and  
420 operable CGE-PLATO Interface Logic System  
421 draw 372,171;40,171;40,138;272,138;272,171  
422 draw 143,155;143,151;160,151;160,155;143,155  
423 draw 348,78;194,132;skip;194,132;skip;192,134;178,148  
424 178,144;182,148;178,148  
425 at 46,165  
426 plot trmn1  
427 at 55,165  
428 plot trmn1  
429 pause  
430 mode erase  
431 draw 348,78;194,132;skip;194,132;skip;192,134;178,148  
432 178,144;182,148;178,148  
433 draw 272,171;40,171;40,138;272,138;272,171  
434 draw 143,155;143,151;160,151;160,155;143,155  
435 at 46,165  
436 plot trmn1  
437 at 55,165  
438 plot trmn1  
439 at 2810  
440 write Location behind the panel of the complete and  
441 operable CGE-PLATO Interface Logic System  
442 mode write
```

----- part=i, block=j -----

block ij, cges2a

```
444 unit cges2a  
445 join cges2b  
446 join cges2c  
447 join cges2d  
448 join cges2e  
449 join cges2f  
450 ***  
451 unit cges2b  
452 draw 50,339;22,345
```

453 at 1101
454 write D8
455 draw 243,397;243,427
456 at 227,427
457 write D1
458 draw 211,397;211,427
459 at 195,427
460 write D2
461 draw 179,397;179,427
462 at 163,427
463 write D3
464 draw 169,352;153,442
465 at 137,442
466 write D7
467 draw 197,352;191,442
468 at 175,442
469 write D6
470 draw 226,352;226,452
471 at 210,452
472 write D5
473 draw 254,352;270,452
474 at 254,452
475 write D4
476 draw 146,333;127,310
477 at 111,290
478 write D9
479 ***

480 unit cges2c
481 at 146,261
482 write D12
483 draw 162,231;162,261
484 draw 224,227;240,267
485 at 224,267
486 write D14
487 draw 218,237;202,277
488 at 186,277
489 write D13
490 draw 198,180;182,160
491 at 166,140
492 write D15
493 draw 81,237;81,267
494 at 65,267
495 write D10
496 draw 113,237;113,267
497 at 97,267
498 write D11
499 ***

500 unit cges2d
501 draw 353,304;370,283
502 at 354,263
503 write D19
504 draw 300,303;292,279
505 at 276,259
506 write D28
507 draw 327,386;327,436

508 at 311,436
509 write D21
510 ***

511 unit cges2e
512 draw 425,333;474,378,
513 at 474,368
514 write D22
515 ***

516 unit cges2f
517 draw 374,204;374,234
518 at 358,234
519 write D16
520 draw 399,214;415,234
521 at 399,234
522 write D17
523 draw 399,194;431,194
524 at 431,184
525 write D18

----- part-1, block-k -----

block_1k, cges3a

527 unit cges3a
528 join cges3b
529 join cges3c
530 join cges3d
531 join cges3f
532 join cges3g
533 join cges3h
534 ***

535 unit cges3b
536 draw 3044;2444;2423;3023;3044
537 at 3023
538 write CIRCUIT BOARD
539 at 176,104
540 write T1 T2 T3 T4 T5
541 at 2723
542 write T6 T7 T8 T9 T10
543 at 176,56
544 write T11 T12 T14 T15
545 ***

546 unit cges3c
547 draw 165,335;153,309
548 at 142,289
549 write T16
550 draw 191,327;191,307
551 at 181,287
552 write T18
553 draw 261,337;245,307

554 at 235,287
555 write T17
556 ***

557 unit cges3d
558 draw 256,215;288,195
559 at 288,185
560 write T22
561 draw 256,225;288,215
562 at 288,205
563 write T21
564 draw 256,235;288,235
565 at 288,225
566 write T20
567 draw 256,245;288,255
568 at 288,245
569 write T19
570 draw 222,185;238,165
571 at 222,145
572 write T23
573 draw 51,237;19,257
574 at 3,257
575 write T24
576 draw 257,185;289,165
577 at 286,148
578 plot ground
579 ***

580 unit cges3f
581 draw 327,294;311,274
582 at 295,254
583 write T28
584 draw 337,294;349,270
585 at 333,250
586 write T27
587 ***

588 unit cges3g
589 draw 393,309;409,279
590 at 393,259
591 write T29
592 draw 452,309;468,289
593 at 468,279
594 write T30
595 ***

596 unit cges3h
597 draw 369,181;353,161
598 at 337,141
599 write T25
600 draw 381,181;389,161
601 at 373,141
602 write T26
603 draw 393,181;402,168
604 at 398,152
605 plot ground

----- part-1, block-1 -----

block 11, cgeend

607 unit cgeend
608 at 710
609 write Now jumping to an Index of CGE Experiments.
610 inhibit jumpch1
611 jumpoutcgeindex
612 stop

----- part-1, block-m -----

User log

613 stop
614 cgedata
615 dn
616 sellers arizona 08/12/74 2
617 0
618
619 -
620 30
621 imsssl stan 08/12/74 1
622 2
623
624 -
625 19
626 imsssl stan 08/12/74 1
627 2
628
629 -
630 19
631 eichmann e 08/13/74 0
632 2
633
634
635 12
636 demo wright 08/13/74 2
637 2
638
639 -
640 08
641 eichmann e 08/13/74 0
642 2
643
644 -
645 12
646 lachman uicc 08/13/74 0
647 1
648
649 -
650 03
651 sample serial 08/13/74 1
652 4

653
654 -
655 16
656 davis matha 08/13/74 0
657 3
658
659 -
660 21
661 student cu 08/14/74 0
662 2
663
664 -
665 00
666 student cu 08/14/74 0
667 2
668
669 -
670 00
671 student cu 08/15/74 0
672 2
673
674 -
675 00
676 visitor ee244 08/16/74 0
677 7
678
679 -
680 12
681 student cu 08/16/74 0
682 2
683
684 -
685 00
686 brown-d siu 08/16/74 0
687 2
688
689 -
690 18
691 wetstone conn 08/16/74 2
692 3
693
694 -
695 06
696 wetstone conn 08/16/74 2
697 3
698
699 -
700 06
701 sample cerl 08/18/74 0
702 3
703
704 -
705 22
706 sample cerl 08/18/74 0
707 3
708
709 -

710 22
711 smith arizona 08/19/74 2
712 0
713 -
714 -
715 28
716 smith arizona 08/19/74 2
717 0
718 -
719 -
720 28
721 cherub block 08/19/74 0
722 2
723 -
724 -
725 11
726 becky cerl 08/20/74 0
727 3
728 -
729 -
730 26
731 becky cerl 08/20/74 0
732 3
733 -
734 -
735 26
736 paul phys 08/20/74 1
737 6
738 -
739 -
740 03
741 ashworth siu 08/22/74 0
742 7
743 -
744 -
745 27
746 ashworth siu 08/23/74 0
747 3
748 -
749 -
750 13
751 ashworth siu 08/23/74 0
752 3
753 -
754 -
755 13
756 dan mathk 08/23/74 0
757 3
758 -
759 -
760 24
761 p mast p 08/23/74 0
762 -
763 -
764 -
765 32
766 martin pdg 08/26/74 0

767
768
769
770 16
771 start

cgeend	cgeend	607	284					
cgeida	cgeid	23						
cgeidb	cgeid	39	45					
cgem&a	cgem&a	47	21	25	37			69
cgem&b	cgem&b	68	49	96	283			
cgem&c	cgem&c	87	78	111	168			
cgem&d	cgem&d	110	89	166				
cgem&de	cgem&d	156	161					
cgem&f	cgem&e	165	160	183				
cgem&g	cgem&e	182	167	198				
cgem&h	cgem&g	197	184	254				
cgem&i	cgem&h	253	199					
cgesia	cgesia	282	255					
cgesib	cgesia	289	182	136	440	144	151	148
cgesia	cgesia	300	133					
cgesia	cgesia	337	137					
cgesid	cgesia	353	141					
cgesie	cgesia	369	145					
cgesif	cgesia	402	149					
cgesig	cgesig	417	152					
cges2a	cges2a	444	159					
cges2b	cges2a	451	445					
cges2d	cges2a	480	446					
cges2d	cges2a	500	447					
cges2d	cges2a	511	448					
cges2d	cges2a	516	449					
cges2d	cges2a	522	159					
cges2d	cges2a	535	528					
cges2d	cges2a	546	529					
cges2d	cges2a	557	530					
cges2d	cges2a	566	531					
cges2d	cges2a	586	532					
cges2d	cges2a	596	533					
Back	panel	158	160					
data	panel	158						
desm	panel	116	124	415				
inc	panel	32	34	35	35			
circu1d	panel	115	122	578	605			
int	panel	31	32	34				
key	panel	150	158	158	158	160	160	161
lab	panel	158						
nc	panel	27	28	28	29	30	32	31
		33	34	34	35	35	36	32
nc1	panel	26	26					
nc2	panel	25	26	27	28	29	30	29
		31	31	32	32	32	33	33
		33	34	34	35	35	36	36
next	panel	158	160					
n1	panel	158	159	200	206	212	227	216
		237	240	244				
n5	panel	129	134	138	142	146	150	247
n6	panel	130	290	294				292

n7	panel	131	135	139	143	147	294	295
n70	panel	120	21	29				
solid	panel	117	126					
station	panel	31	32	34	35			
switch	panel	113	120	308	351	359	400	
trmn1	panel	114	118	310	312	314	320	316
		324	345	347	349	361	367	363
		379	381	383	385	387	396	389
		409	411	413	426	428	436	438
v3	panel	34	35					

lesson information

lesson name = cge

starting date = 07/17/73

last edited on 08/26/74 at 11.31.45

by Neal of course eedge

at site 7, station 27

author name = J. P. Neal

department = E.E.

telephone number = 333-4351

discipline = Elec. Engineering

grade level = Any

description of lesson = A Description of the CGE-PLATO Instructional Laboratory.

lesson cgerl at 2:15 am on tuesday, august 27, 1974

----- part=1, block=a -----

block 1a, cgerlid

2 stop
3 **** For Neal, CGERL, Room 248, EEB.

4 One line description of this lesson --.

5 CGE-PLATO Tests & Special Software Routines

6	Divisions of this Lesson:	Block	Unit
7	Id for this lesson	cgerlid	
8	Access from the student mode	rlm0a	rlm0a
9	Cge index of lessons	rlm0a	rlm1a
10	Listing of connections	rlm0a	rlm2a
11	Cc test	rlm3a	rlm3a
12	Listing of dial settings	rlm3a	rlm4a
13	Do test	rlm5a	rlm5a
14	Transmit over ext channel	rlm5a	rlm6a
15	Repeated check of 1 dial	rlm5a	rlm7a
16	Cge checker authoring aids	rlm7b	rlm8a
17	Slide display	rlm9a	rlm9a
18	Cge software record-maintenance	rlm10a	rlm10a

19 final edit 21 aug 74 neal.

20 *list info
21 *list symbols
22 *list varian,charset,cgeindex,cgechar
23 ****
24 start
25 ext 0 \$\$ clears cge hardware
26 dataoff

----- part=1, block=b -----

block 1b, rlm0a.

28 unit rlm0a
29 course n51
30 jump ((n51='eece')\$and\$user='author'),x,rlm0b
31 back rlmend
32 base
33 erase
34 at #11
35 write Type the number of the following topic in
36 which you are interested:

- 37 1. Index to CGE Lessons and Stations
38 2. Listing of Current Connections
39 3. CC Test
40 4. Listing of Current Dial Settings
41 5. DC Test
42 6. Transmit Data over External Channel
43 7. Repeated Check of a Selected Dial
44 8. CGE Checker Authoring Aids
45 9. Slide Display
46 10. CGE Software Record-Maintenance

47 arrow 2725
48 match n150,1,2,3,4,5,6,7,8,9,10
49 jump n150,x,rlm1a,rlm2a,rlm3a,rlm4a,rlm5a,rlm6a,rlm7a,rlm8a,rlm9a,rlm10a
50 ***.

51 unit rlm0b
52 jumpout plato
53 ***.

54 unit rlm1a
55 base
56 back rlm0a
57 next rlm0a
58 at 305

CGE-PLATO LESSONS

LESSON	TOPIC
cge	A Description of the CGE-PLATO Instructional Lab.
cgerl	CGE-PLATO Tests & Special Software Routines
ee244	Student List for CGERL Course
eecege	Author List for CGERL Course
ogeindex	Router Lesson for Courses ee244 and eecege
cgedata	Data File for courses ee244 and eecege
eex00	An Introduction to the CGE Station
eex01	The Oscilloscope
eex02	The Audio Oscillator
eex03	The Function Generator
eex04	The Constant Voltage/Constant Current Supply
eex05	The Vacuum Tube Voltmeter
eex06	Measurements of Transients
eex07	Measurements of Impedance
eex08	Measurements of Two-Port-Networks
at	2603
write	CGE-PLATO stations in CGERL at 248 EEB:

79 Site 7, Station 12, Console #118 w/o experimental equipment
80 Site 7, Station 27, Console #324 w/CGE-PLATO I/O & exp. eqpt.
81 ***.

82 unit rlm2a
83 base
84 back rlm0a
85 next rlm2a
86 join rlm2b
87 at 3112
88 write Press -NEXT- to check connections again.

-----, part=1, block=c -----

```

    block 1c, rlm2b

91 unit      rlm2b
92 define    rlm2b
93          cc=o40
94          check=n1      $$ marks a checked terminal
95          start=n2       $$ first terminal in a node
96          termc=n3       $$ marks terminal to be examined
97          keytime=v4     $$ records time since last key
98          dataac=n5      $$ stores data from key
99          namterm=n6     $$ name of terminal to be displayed
100         screen=n7
101         node=n8
102         at            310
103         write         LISTING of CURRENT TERMINAL INTERCONNECTIONS
104         calc          check<=0
105         start<=termc+1
106         keytime<clock
107         screen<=320
108         node<=0
109         time          1
110         enable
111         ext           cc+termc      $$ first request for terminal data
112         entry         rlm2c
113         pause
114         goto          (key=timeup) - (key=next$or$key=stop),rls2a,x,rls2b,
115         goto          (key$mask$01000)=0,rlm2c,x  $$ locks out keyboard
116         calc          dataac$key$mask$037   $$ bottom 5 bits are data bits
117         check<check$union$(1$cls$(termc-1))  $$ marks terminal
118         keytime<clock
119         goto          dataac=start,rls2c,x
120         goto          (termc=start)$and$node=6,rls2e,x
121         writec        n3=n2,(at,-5+n7+n7+200)Terminals Connected to NODE <a,07000+n8+n8+1>,
122         size          0
123         calc          namterm<termc
124         calc          termc=start,screen<=screen+100,screen<=screen
125         at
126         join         termc=start,rls2d,
127         calc          namterm<dataac
128         at
129         join         rls2d
130         goto          where>3000,rls2e,x
131         calc          termc<dataac
132         ext           cc+termc
133         goto         rlm2c
134         ***

135 unit      rls2a

```

```

136 time 1
137 goto. (clock-keytime>1.5),x,rlm2c
138 calc keytime=clock
139 ext cc+termc
140 goto rlm2c
141 *** r

142 unit rls2b
143 pause

144 entry rls2e
145 ext 0
146 writec (bitcnt (check)<30)-(screen=320),,screen+198>* AND MORE *,
147 ,,screen+200>* CHECK COMPLETED *,
148 ,,screen+394>* Terminals are not interconnected *
149 size 0
150 ***

151 unit rls2c
152 goto start≥30,rls2e,x
153 calc start=start+1
154 calc termc=start
155 goto (check$ars$(start-1)$mask$1)=0,x,rls2c
156 ext cc+termc
157 goto rlm2c
158 ***

159 unit rls2d
160 writec namterm,,Term 1,Term 2,Term 3,Term 4,Term 5,Term 6,Term 7,
161 Term 8,Term 9,Term 10,Term 11,Term 12,GROUND,Term 14,
162 Term 15,Scope: A input,Scope: B input,Scope: Trigger,
163 Fun-gen: Sqr-wave output,Fun-gen: Trng-wave output,
164 Fun-gen: Sine-wave output,Fun-gen: Ramp output,
165 Fun-gen: Atten'd output,Fun-gen: Trigger output,
166 DC-sup: (+) term.,DC-sup: (-) term,Aud-osc: Right output
167 Aud-osc: Left output,VTVM: input,VTVM: output

```

----- part=1, block=d -----

block 1d, rlm3a

```

169 unit rlm3a
170 define rlm3a
171 cc=040
172 termc=n1-9
173 at 227
174 write CC Test
175 at 318
176 write (Press -DATA- to restart)
177 at 604
178 write term octal decimal
179 at 634
180 write term octal decimal
181 calc n1≠10

```

```

182 calc v58@v52@clock
183 n51@0
184 time 1
185 enable
186 ext cc+termc

187 entry rlm3b
188 pause
189 goto (key=timeup)-(key=next$or$key=stop),rlm3c,x,rlm3d
190 calc n(n1)@key
191 n1+n1+1
192 v50@clock
193 goto termc>30,rlm3d,x
194 ext cc+termc
195 goto rlm3b
196 ***
197 unit rlm3c
198 time 1
199 goto clock-v50>1.5,k,rlm3b
200 calc v50@clock
201 n51+n51+1
202 ext cc+termc
203 goto rlm3b
204 ***
205 unit rlm3d
206 ext 0
207 calc v53@clock
208 at 3010
209 write Number of DATA Transmission Repeats =
210 shout n51
211 at 3110
212 write Total DATA Transmission Time =
213 shout v53-v52,4.3
214 write seconds.
215 calc n4@0
216 n3#605
217 do rlm3f,n2@1,(n1-10)+2
218 calc n3#635
219 do rlm3f,n2=((n1-10)+2+1),n1-10

220 entry rlm3e
221 pause
222 jump (key=next$or$key=back)-(key=data),rlm3a,x,rlm3a
223 goto rlm3e
224 ***
225 unit rlm3f
226 calc n3+n3+100
227 n145+n2
228 at n3
229 shout n2,2
230 write
231 shout n(n2+9),4
232 at n3+9
233 calc n99+n(n2+9)$mask$077

```

```
234 showt n99  
235 ***  
  
236 unit rlm4a  
237 base rlm8a  
238 back rlm4a  
239 next rlm4a  
240 join rlm4b  
241 at 3115  
242 write Press -NEXT- to check dials again.  
243 Press -BACK- when done.
```

~~part-1, block-e~~

block ie, rlm4b

```
245 unit rlm4b  
246 define rlm4b  
247 dc=o$000  
248 dial=n1  
249 code=n2  
250 screen=n3  
251 keytime=v4  
252 calc n22+nc2+nc2+1  
253 do rlm4c  
254 calc screen=511  
255 dial+1  
256 keytime=clock  
257 time 1  
258 enable  
259 ext dc+dial  
  
260 entry rlm4d  
261 pause  
262 goto (key=timeup) - (key=next$or$key=stop),rlm4e,x,rlm4f  
263 goto (key$mask$0$000)=0,rlm4d,x //$$ locksout keyboard  
264 calc code+key$mask:$037  
265 keytime=clock  
266 do rlm4g //$$ generates display  
267 calc dial+dial+1  
268 goto dial>22,rlm4f,x  
269 ext dc+dial  
270 goto rlm4d  
271 ***  
  
272 unit rlm4e  
273 time 1  
274 goto clock-keytime>1.5,x,rlm4d  
275 calc keytime=clock  
276 ext dc+dial  
277 goto rlm4d  
278 ***  
279 unit rlm4f
```

```

288 ext 8
281 exit 1
282 ***
283 unit rlm4g
284 at screen+screen+100
285 writec dial,,,PLUG-IN,,,SCOPE,,FUN-GEN,,,
286 DC-SUP,,,AUD-OSC,,,VTVM
287 at screen+8
288 writec dial,,,B VOLTS,TIME,A VOLTS,B FREAMP,
289 SWEEP MODE,TRIGGER-SOURCE,A PREAMP,
290 Y DISPLAY FUNC,X DISPLAY FUNC,
291 TRIGGER,MULTIPLIER,CYCLES/SEC,
292 OUTPUT,ATTENUATOR,DC LEVEL,METER,
293 VOLTAGE,CURRENT,AMPLITUDE,
294 RANGE,FREQUENCY,RANGE
295 at screen+23
296 do dial,x,x,d1,d2,d1,d4,d5,d6,d4,d8,d9,d10,x
297 do dial-10,x,x,d11,d12,d13,d14,d15,d16,d17,d18,d19,d20,d21,d22
298 ***
299 unit d1
300 writec code,-,0,1 m,2 m,5 m,10 m,20 m,50 m,0.1 ,0.2 ,0.5 ,
301 1.0 ,2.0 ,5.0 ,10 ,20 ,50 ,100 ,200
302 write V full scale
303 ***
304 unit d2
305 writec code,-,0,10 u,20 u,50 u,100 u,200 u,500 u,
306 1 m,2 m,5 m,10 m,
307 20 m,50 m,100 m,200 m,500 m,1,2,5,10,20,50,ext
308 write sec. full scale
309 ***
310 unit d4
311 writec code,-,0,-AC,+AC,+DC,-DC,OFF,BAL SET
312 ***
313 unit d5
314 writec code,-,0,ARM - variable length,
315 NAN - variable length,
316 AUTO - variable length,
317 DPIV - variable length,
318 DRIV - variable sweep rate,OFF
319 ***
320 unit d6
321 writec code,-,0,LINE,AC - ext + 20,DC - ext + 20,AC - ext,
322 ext,AC - int,DC - int.,
323 writec code-8,OFF.

```

----- part=1, block=f -----

block 1f. rlm4g

325 unit rlm4c
326 at 419
327 write Dial Current Setting
328 at 419
329 write ----
330 ***

331 unit d8
332 writeec code,-,0,A,B,A & B (CHOP),A & B (ALT);A vs B
333 ***

334 unit d9
335 writeec code,-,0,SWP×5,SWP,EXT
336 ***

337 unit d10
338 writeec code,-,0,INT,EXT
339 ***

340 unit d11
341 write times
342 writeec code,-,0,0.001,0.01,0.1,1.0,10,100,1000,
343 ***

344 unit d12
345 writeec code,-,0.1.1,1.5,1.9,2.3,2.7,3.2,3.6,4.1,4.5,
346 5.0,5.4,5.9,6.3,6.8,7.2,7.7,8.0,8.5,9.0,9.4,9.9,10.2
347 write Hz (not incl. MULT.)
348 ***

349 unit d13
350 writeec code,-,0,RAMP,SINE,TRIANGLE,SQUARE,
351 ***

352 unit d14
353 writeec code,-,0.2.7,3.5,4.8,6.1,7.2,8.1,8.7,9.8,10.4,11.1,11.5,
354 12.0,12.5,13.0,13.3,13.5,14.0,14.1,14.4,14.8,15.0,15.1
355 write volts
356 ***

357 unit d15
358 writeec code,-,0,0.0,0,-56.5,-55.5,-52.5,-48,-44,-39,-35,-31,-27,
359 -24,-20,-17,-14,-13,-10,2,30,56
360 write volts
361 ***

362 unit d16
363 writeec code,-,0,VOLTS,AMPS,
364 ***

365 unit d17
366 writeec code,-,0,0.1,0.9,3.3,5.6,8.2,11.0,13,15,17,20,21,23,26,
367 28,30,32,34,36,38,40,42,44
368 write volts
369 ***

```

370 unit d18
371 writec code,-,0,0.0,0.0,0.01,0.05,0.07,0.10,0.14,0.17,0.20,0.25,
372 . . . 0.27,0.29,0.31,0.35,0.37,0.40,0.43,0.46,0.50,0.52,0.55,0.59.
373 write amperes
374 ***

375 unit d19
376 writec code,-,0,0.04,1.0,2.0,4.0,6.0,8.0,9.0,10,11,12,14,15,17,
377 19,20,21,23,25,26,28,29,30
378 write volts rms
379 ***

380 unit d20
381 write times
382 writec code,-,0,1,10,100,200,
383 ***
384 unit d21
385 writec code,-,0,17,19,2,20,5,21,8,23,4,25,4,28,31,2,35,
386 40,46,53,61,71,82,
387 94,108,122,140,160,185,210
388 write Hz (not incl. RANGE)
389 ***

390 unit d22
391 writec code,-,0,0.001,0.003,0.01,0.03,0.1,0.3,1.0,3.0,10,30,
392 100,300
393 write R.M.S. VOLTS full scale

```

----- part-1, blocking -----

block fig. rlm5a

```

395 unit rlm5a
396 define rlm5a
397 dc=0100
398 dial=n1-9
399 base
400 at 128
401 write DC Test
402 at 218
403 write (Press -DATA- to restart)
404 calc n1<10
405 n101<00      $$ counter for number of repeats
406 time 1        $$ time slice between repeats
407 calc v100<clock
408 calc v102<clock
409 ext dc+dial
410 enable
411 goto rlm5b
412 entry rlm5c
413 ext dc+dial

```

```

414 entry rlm5b
415 pause
416 goto key-timeup,rlm5f,x    $$ go to rlmrf for retry
417 calc n(n1+1)<key
418      n1+n1+1
419      v100>clock
420 goto key=next$or$dial>22,x,rlm5c
421 ext 0
422 calc v103>clock
423 calc n4#0
424 at 410
425 write Dial Alpha Octal Binary
426 do rlm5d,n2+1,27
427 at 3010
428 write Number of Repeats=
429 shout n101
430 at 3110
431 write Total Transmission Time=
432 shout v103-v102, 4.3
433 write seconds.
434 back rlm5a
435 next rlm5a
436 data rlm5a
437 ***

438 unit rlm5d
439 calc n3#400+100*n2
440 at n3+12
441 write at,n3+2> {a,n(n2+10)$mask$077} / <at,n3+28> {o;n(n2+10),4}
442 at where+7
443 do rlm5e,n120+1,2
444 at where
445 do rlm5e,n120#3,10
446 exit - (n2#n1-10)
447 ***

448 unit rlm5e
449 shout (n(n2+10)$ars$(10-n120))$mask$01,1
450 ***

451 unit rlm5f      $$ handles retries
452 time 1
453 goto clock-v100>2,x,rlm5b
454 calc v100>clock
455      n101#n101+1
456 ext do+dial
457 goto rlm5b
458 ***

459 unit rlm5a
460 back rlm5a
461 erase
462 at 510
463 write Enter the code which you wish to transmit
464 over the external channel.
465 next rlm5a
466 arrow 910

```

467 store n1
468 ok
469 at 1210
470 write Press -NEXT- to transmit same code again.
471 Press -BACK- to transmit a different code.
472 inhibit erase
473 jump rlm6c
474 ***

475 unit rlm6b
476 at 1210
477 write EXT OUTPUT
478 back rlm6a
479 next rlm6b
480 ext n1
481 at 1510
482 showo n1,5
483 ***

484 unit rlm6c
485 inhibit erase
486 ext n1
487 back rlm6a
488 next rlm6c
489 ***

490 unit rlm7a
491 back rlm7a
492 ext 0
493 at 510
494 write Type the CGE number of the dial you wish to
495 have checked repeatedly.
496 arrow 814
497 store n20
498 ok
499 jump rlm7b

----- part-i, block-h -----

block 1h, rlm7b

501 unit rlm7b
502 at 210
503 write REPEATED CHECK of a SINGLE DIAL
504
505 Press -STOP- to stop test.

506 Then, press -NEXT- to chose another dial,
507 or -BACK- to return to index.
508 at 914
509 write Dial Number = <z,n20>
510 at 933
511 write Code =
512 at 1139

```

513 write Code Time
514 at 1314
515 write Total checks =
516 Changes =
517 Repeats =
518 at 1814
519 write Total time =
520 Time/Check =
521 mode rewrite,
522 enable
523 ext o100+n20
524 pause
525 calc n3$key$mask$077
526 calc n2+n6+0
527 n1+1
528 n11+0
529 n12+0
530 n13+1240
531 v7<clock
532 v5<clock
533 time 1
534 ext o100+n20

535 entry rlm7be
536 pause
537 calc v10<clock
538 calc n13+n13+100
539 goto n13>3200,rlm7bf,x
540 at n13
541 write {z,n3} {z,v10-v7}

542 entry rlm7bf
543 goto (key=stop$or$key=next),rlm7c,x
544 goto key$timeout,rlm7d,x
545 goto (key$mask$010000)=0,rlm7be,x $$ locks out keyboard
546 calc n3=key$mask$077,n12+n12,n12+n12+1
547 calc n3$key$mask$077
548 at 940
549 showa key$mask$077
550 at 944
551 write o10,key,4>
552 calc n1+n1+1
553 calc v8<clock
554 at 1829
555 write {z,n1}
      {z,n6}
      {z,n12}
556 at 1829
557 write {z,v8-v7}
558 at {z,(v8-v7)+n1}
559 write {z,(v8-v7)+n1}
560 calc v5<clock
561 calc v8<clock
562 ext o100+n20
563 goto rlm7be
564 end

565 unit rlm7c
566 calc v8<clock

```

567 ext \$
568 pause
569 mode rewrite
570 at 1329
571 write <z,n1>
572 <z,n6>
573 <z,n12>
574 at 1829
575 write <z,v8->
576 <z,(v8-v7)+n1>
577 at 2214
578 write CHECK COMPLETED

579 entry rlm7ce
580 pause \$\$ loop absorbs spurious keys
581 goto key=next\$or\$key=back,x,rlm7ce
582 jump key=next,rlm7a,rlm8a
583 ***

584 unit rlm7d
585 time 1
586 goto clock-v5>1,x,rlm7be
587 calc n6+n6+1
588 v5+clock
589 ext o100+n20
590 goto rlm7be

591 unit rlm8a
592 erase
593 back rlm8a
594 at 510
595 write CGE Checker Authoring Aids

This demonstration is intended to give authors
an opportunity to explore the use of the ckc and
ckd series subroutines.

596 Press c for connection check subroutine demo.

600 Press d for dial check subroutine demo.

601 at 2210
602 write NOTE: Authors in the student mode can press -MICRO-
603 to pass OK through a check. Students cannot do this.
604 arrow 1910.
605 long 1
606 answer c
607 jump rlm8b
608 answer d
609 jump rlm8e

----- part=1, block=i -----

block ii, rlm8b

611 unit rlm8b
612 erase
613 inhibit erase
614 back rlm8a
615 next rlm8b
616 at 510
617 write - Connection Check Subroutine Demonstration

618 Current Author Codes
619 at 910
620 write Author Code n33= {a,n33,30}

621 Best Match = {a,n36,30}

622 Hardware Code =
623 at 1428
624 do rlm8c,n75+1,30
625 at 1610
626 write Press DATA to change Author Code
627 data rlm8d
628 at 1910
629 write Type the number of the cko subroutine you wish to try.

630 1) cko (performs a connection check)
631 2) ckow (performs a CC and writes errors)
632 3) ckci (counts errors of new pack vs cko)
633 4) ckciw (same as ckci and writes errors)
634 5) ckc2 (counts errors of best match vs cko)
635 6) ckc2w (same as ckc2 and writes results)
636 arrow 2810
637 long 1
638 specs nookno
639 match n51,1,2,3,4,5,6
640 join n51,x,cko,ckow,ckci,ckciw,ckc2,ckc2w,
641 at 3110
642 write {z,-n47} Errors Found in Setup
643 back rlm8b
644 ***

645 unit rlm8c
646 calc n76+0
647 move n30,n75,n76,10
648 calc ((n76=0) - (n76="0")),n76+"0",n76+n76,n76+"4"
649 showa n76
650 ***

651 unit rlm8d
652 at 1010
653 write Desired Code
654 arrow 1026
655 copy n33,30
656 long 30
657 storea n33,30
658 ok
659 jump rlm8b

```

660 ***
661 unit rlm8e
662 erase
663 inhibit erase
664 base
665 back rlm8a
666 next rlm8e
667 at 510
668 write      Dial Check Subroutine Demonstration

669          Current Author Codes
670 at 910
671 write Author Code n33=
672 at 928
673 write <a,n33,50>
674
675
676 at 1310
677 write Best Match = <a,n39,50>
678
679 Hardware Code = <a,n80,22>
680 at 1710
681 write Press DATA to change Author Code.
682 data rlm8f
683 at 1910
684 write Type the number of the ckd subroutine you wish to try.

685      1) ckd      (performs a dial check)
686      2) ckdw     (performs a DC and writes errors)
687      3) ckd1     (counts errors of new pack vs ckd)
688      4) ckd1w    (same as ckd1 and writes errors)
689      5) ckd2     (counts errors of best match vs ckd)
690      6) ckd2w    (same as ckd2 and writes results)
691 arrow 2810
692 long 1
693 match n51,1,2,3,4,5,6
694 join n51,x,ckd,ckdw,ckd1,ckd1w,ckd2,ckd2w
695 at 3110
696 write <z,-n47> Errors Found in Setup
697 back rlm8e
698 ***

699 unit rlm8f
700 at 1110
701 write Desired Code
702 arrow 1126
703 copy n33,50
704 long 50
705 storea n33,50
706 ok
707 end

```

----- part=1, block=j -----

block ij, rlm9a

709 unit rlm9a
710 back rlm9a
711 next rlm9b
712 calco (station=251),n101+256,512
713 slide noslide
714 at 107
715 write SLIDE NO. CGE SLIDE

716 0 Test Slide
717 1 CGERL Entrance
718 2 The EE244 Laboratory
719 3 CGE-PLATO System Description
720 4 Orientation of the CGE Station
721 5 Scope & Function Generators
722 6 Aud. Osc., VTVM, & DC Supply
723 7 Layout of Sensed Dials & Terminals
724 8 List of Sensed Dials & Terminals
725 9 - 18 Dial Setting Codes
726 19 Resistor Color Code
727 20 - 21 E'E Symbols & Units
728 22 Recommended Unit Prefixes
729 23 Defined Physical Values
730 24 - 26 Physical Constants
731 27 - 32 SCOPE - Use of Dials and Terminals
732 33 - 35 SCOPE - Manufacturer's Specifications
733 36 - 44 PLUG-IN - Use of Dials and Terminals
734 45 - 58 PLUG-IN - Manufacturer's Specifications
735 51 - 53 FUN:GEN. - Use of Dials and Terminals
736 54 - 56 FUN:GEN. - Manufacturer's Specifications
737 57 - 60 AUD:OSC. - Use of Dials and Terminals
738 61 - 62 AUD:OSC. - Manufacturer's Specifications

739 Press -NEXT- to see remainder of Slide List:

----- part=1, block=k -----

block ik, rlm9b

741 unit rlm9b
742 back rlm9a
743 next rlm9c
744 calco (station=251),n101+256,512
745 slide noslide
746 at 107
747 write SLIDE NO. CGE SLIDE

748 63 - 66 VTVM - Use of Dials and Terminals
749 67 - 68 VTVM - Manufacturer's Specifications
750 69 - 71 DC SUPP - Use of Dials and Terminals
751 72 - 75 DC SUPP - Manufacturer's Specifications

752 76 Graph of a Transient
753 81 CGE Station Picture

754 88 Gunther Frank at CGE
755 89 Doug Dowden & Frank at CGE
756 90 Dave Borth at CGE
757 91 Doug Zanter & Borth at CGE
758 92 Borth & Dan Derrig at CGE
759 93-97 CGE-PLATO Interface

760 Type slide no. , press -NEXT-, or -BACK- to return.

761 arrow 3121
762 store n100
763 ok
764 erase
765 goto (n100≤255),rlm9c,rls9a
766 ***

767 unit rls9a
768 back rlm9a
769 next rlm9a
770 at 1210
771 write NO! Type a number less than 256..
772 ***

773 unit rlm9c
774 back rlm9a
775 next rlm9d
776 at 3204
777 write This is slide {z,n100}. Press -NEXT- for next slide
778 slide n100
779 ***

780 unit rlm9d
781 back rlm9a
782 next rlm9a
783 calc n100+n100+1
784 goto (n100≤255),rlm9c,x
785 slide 512
786 at 1210
787 write You can't show a slide greater than 255.
788 ***

789 unit rlm9e
790 slide n100+512
791 back rlm9a
792 next rlm9a
793 goto rlm9a

----- part=1, block=1 -----

block 11, rlm10a

795 unit rlm10a
796 back rlm0a
797 next rlm0a
798 *calc nc(1)+10033 \$\$ format for changing cc counter
799 *calc nc(2)+11869 \$\$ format for changing dc counter
800 at 505
801 write

CGE Software Record-Maintenance

802 CAUTION: In order to avoid interference with automatic
803 record-keeping and avoid loss of log records, the
804 following tasks will only be performed by a CGE author
805 specifically authorized by the Director of CGERL.

806 If specifically authorized, select the operation
807 you wish to perform:

808 A. Record chronologically a remark in the cgedata record.

809 B. Print and clear the uselog maintained in the common
810 in lesson cge:

811 C. Print and clear the statlog maintained in lesson
812 cgeindex.

813 arrow 2810
814 long 0
815 specs bumpshift
816 match n150,a,b,c
817 jump n150,x,rlm10b,rlm10c,rlm10d
818 ***

819 unit rlm10b

820 calc n21+nc(4)

821 nc(4)+nc(4)+3

822 nc(n21)+'inst

907

At the beginning of each day of operation, type
the present date or, to record a note about a student
difficulty, type the student's name.

824 arrow 1311

825 long 0

826 storea nc(n21+1)

827 ok

828 at 1509

Type the desired code or remark:

829 ok - CC and DC checked and new day started.

830 pdn - Plato down.

831 cdn - CGE hardware down.

832 unkabs - unexcused absence.

833 xabs - excused absence.

838 or 'any other 8 character remark.
839 arrow 2911
840 long 8
841 storea nc(n21+2)
842 ok
843 jumpout plato
844 ***

845 unit rlmigc
846 next rlmga
847 back rlmga
848 at 806

849 write The uselog in cge should be printed when 388
850 lines have been entered therein. Do this as follows:

851 1. Copy the common, uselog, from cge into cgerl as
852 block 1b, rename it userlog, convert it to a source,
853 and mark it so it will not be readin.

854 2. Insert "*list label, user log (date)" as the
855 first line in userlog and "*list off" as the last
856 line in userlog in cgerl.

857 3. Request a print of cgerl.

858 4. Enter cge, convert the common uselog to a source,
859 delete all entries, then reconvert uselog to a common
860 so it can continue to record users of lesson cge.

861 5. After the print of the userlog in cgerl has been
862 received, delete the block userlog from cgerl.

----- part-1, block=m -----

block 1m, rlmend

864 unit rlmigd
865 help1 rlmigc
866 lab1 rlmigi
867 next rlmga
868 back rlmga
869 at 506

870 write The statlog in cgeindex should be printed when 388
871 lines have been entered therein. Do this as follows:

872 1. Warning- this step must be done only once !!!
873 Convert the common, statlog, to printable form from
874 here by pressing -HELP1-, once.

875 2. Copy the common statlog into cgerl, convert it to
876 a source, rename the block studstat, move it to
877 block 1b, and mark it not to be readin.

878 3. Zero the original copy of the common by pressing

879 -LAB1- while in here in the student mode.
 880
 881 5. Enter *list label,student statistics (date) as
 882 the first line in studstat, and *list off* as
 the last line in studstat.
 883
 884 6. Request a print of lesson cger1.
 885
 886 ***
 887 unit rlm10e
 888 calc n1+1
 889 entry rlm10e1
 890 calc n15@=nc(n1-1)
 891 calc n15@='inst',n1+n1+3,n1+n1
 892 jump n15@='inst',rlm10e1,x
 893 itoa nc(n1+1),nc(n1+1)
 894 itoa nc(n1+2),nc(n1+2)
 895 itoa nc(n1+3),nc(n1+3)
 896 itoa nc(n1+4),nc(n1+4)
 897 itoa nc(n1+6),nc(n1+6)
 898 jump rlm10g
 899 ***
 900 unit rlm10f
 901 calc n1+n1+8
 902 jump n1≤322,rlm10e1,x
 903 at 410
 904 write Common is now printable.
 905 pause
 906 jumpout plato
 907 ***
 908 unit rlm10g
 909 calc v50@=vc(n1) \$\$ chgd from n1+5 so counters prt.
 910 calc n51@=int(v50)
 911 calc n52@=100000×frac(v50)
 912 jump n51≤9,rlm10g1,x
 913 jump n51≤99,rlm10g2,x
 914 jump n51≤999,rlm10g3,x
 915 entry rlm10g1
 916 calc n53@1
 917 goto rlm10h
 918 entry rlm10g2
 919 calc n53@2
 920 goto rlm10h
 921 entry rlm10g3
 922 calc n53@3
 923 goto rlm10h
 924 ***

925	unit	rlm18h		
926	calc	n54+1		
927	itoa	n51,n51		
928	itoa	n52,n52		
929	move	n54,1,n51,n53+1,1		
930	move	n52,1,n51,n53+2,4		
931	calc	nc(n1+5)+n51		
932	jump	rlm18f		
933	***			
934	unit	rlm18i		
935	calc	nc(4)+18		
936	zero	nc5,318		
937	calc	nc322+8		
938	jump	rlm18a		
939	***			
940	unit	rlmend		
941	press	next		
942	end	lesson		
943	***			
944	use	eex00,ck1		
945	use	ck2		
946	use	ck3		
947	use	ck4		
948	use	ck5		
	ckc	not found	640	
	ckcw	not found	640	
	ckc1	not found	640	
	ckc1w	not found	640	
	ckc2	not found	640	
	ckc2w	not found	640	
	ckd	not found	694	
	ckdw	not found	694	
	ckdi	not found	694	
	ckdiw	not found	694	
	ckd2	not found	694	
	ckd2w	not found	694	
d1	rlm4b	299	296	296
d10	rlm4c	337	296	
d11	rlm4c	348	297	
d12	rlm4c	344	297	
d13	rlm4c	349	297	
d14	rlm4c	352	297	
d15	rlm4c	357	297	
d16	rlm4c	362	297	
d17	rlm4c	365	297	
d18	rlm4c	370	297	
d19	rlm4c	375	297	
d2	rlm4b	384	296	
d20	rlm4c	380	297	
d21	rlm4c	384	297	
d22	rlm4c	390	297	
d4	rlm4b	310	296	296
d5	rlm4b	313	296	
d6	rlm4b	320	296	
d8	rlm4c	331	296	

R9	rlm4c	334	296					
rlmend	rlmend	948	31					
rlm8a	rlm8a	20	56	57	84	494	222	735
			498	491	582	791	593	792
			793	796	797	867	846	865
			936					847
rlm8b	rlm8a	51	38					
rlm1a	rlm8a	54	49					
rlm10a	rlm10a	795	49					
rlm10b	rlm10a	819	817					
rlm10c	rlm10a	845	817					
rlm10d	rlmend	864	817					
rlm10e	rlmend	887	865					
rlm10el	rlmend	889	892	902				
rlm10f	rlmend	900	932					
rlm10g	rlmend	908	898					
rlm10g1	rlmend	915	912					
rlm10g2	rlmend	918	913					
rlm10g3	rlmend	921	914					
rlm10h	rlmend	925	917	928	923			
rlm10i	rlmend	934	866					
rlm2a	rlm2a	82	49	85				
rlm2b	rlm2b	91	86					
rlm2c	rlm2b	112	115	133	137*	148		157
rlm3a	rlm3a	169	49	222				
rlm3b	rlm3a	187	195	199	203			
rlm3c	rlm3a	197	189					
rlm3d	rlm3a	205	189	193				
rlm3e	rlm3a	220	223					
rlm3f	rlm3a	225	217	219				
rlm4a	rlm3a	236	49	239				
rlm4b	rlm4b	245	240					
rlm4c	rlm4c	325	253					
rlm4d	rlm4b	260	263	278	274	277		
rlm4e	rlm4b	272	262					
rlm4f	rlm4b	279	262	268				
rlm4g	rlm4b	283	266					
rlm5a	rlm5a	395	49	436				
rlm5b	rlm5a	414	411	453	457			
rlm5c	rlm5a	412	420					
rlm5d	rlm5a	438	426					
rlm5e	rlm5a	448	443	445				
rlm5f	rlm5a	451	416					
rlm6a	rlm5a	459	49	465	478	487		
rlm6b	rlm5a	475	479					
rlm6c	rlm5a	484	473	488				
rlm7a	rlm5a	490	49	582				
rlm7b	rlm7b	501	499					
rlm7be	rlm7b	535	545	563	586	590		
rlm7bf	rlm7b	542	539					
rlm7c	rlm7b	565	543					
rlm7ce	rlm7b	579	581					
rlm7d	rlm7b	584	544					
rlm8a	rlm7b	591	49	614	665			
rlm8b	rlm8b	611	607	615	643	659		
rlm8c	rlm8b	645	624					
rlm8d	rlm8b	651	627					

rlm8e	rlm8b	661	689	666	697
rlm8f	rlm8b	690	682		
rlm9a	rlm9a	289	49	742	768 781 769 782 774
rlm9b	rlm9b	741	711		
rlm9c	rlm9b	773	743	765	784
rlm9d	rlm9b	788	775		
rlm9e	rlm9b	789			
rls2a	rlm2b	135	114		
rls2b	rlm2b	142	114		
rls2c	rlm2b	151	119	155	
rls2d	rlm2b	159	126	129	
rls2e	rlm2b	144	128	130	152
rls9a	rlm9b	767	765		
back	rlm3a	222			
back	rlm5a	581			
bitcnt	rlm2b	146			
cc	rlm2b	93	111	132	139 156
cc	rlm3a	171	186	194	202
check	rlm2b	94	104	117	146 155
clock	rlm2b	106	118	137	138
clock	rlm3a	182	192	199	200 207
clock	rlm4b	256	265	274	275
clock	rlm5a	407	408	419	422 453 532 454 537 531
		553	561	566	586 588
code	rlm4b	249	264	308	305 311 323 314 332 321
		335	398	342	345 350 363 353 366 358
		371	376	382	385 391
data	rlm3a	222			
datac	rlm2b	98	116	119	127 131
do	rlm4b	247	259	269	276
do	rlm5a	397	409	413	456
dial	rlm4b	248	255	259	267 276 268 285 269
		288	296	297	
dial	rlm5a	398	409	413	428 456
frac	rlm5a	911			
fmt	rlm5a	910			
key	rlm2b	114	114	114	115 116
key	rlm3a	189	189	189	190 222 222 222
key	rlm4b	262	262	262	263 264
key	rlm5a	416	417	428	525 543 549 543 546 544
		547	549	551	581 581 582
keytime	rlm2b	97	106	118	137 138
keytime	rlm4b	251	256	265	274 275
n	rlm3a	190	231	233	
n	rlm5a	417	441	441	449
namterm	rlm2b	99	123	127	160
nc	rlm5a	820	821	821	822 829 931 841 935 890
nc2	rlm4b	252	252		
nc322	rlm5a	937			
nc5	rlm5a	936			
next	rlm2b	114			
next	rlm3a	189	222		
next	rlm4b	262			
next	rlm5a	420	543	581	582 941
node	rlm2b	101	108	120	
noslide	rlm5a	713	745		
n1	rlm2b	94			

n1	r1m3a	172	181	198	191	191	217	219	219
n1	r1m4b	240							
n1	r1m5a	398	484	417	418	418	480	446	482
		486	587	552	552	555	576	568	571
		840	891	891	891	891	902	901	901
		931							
n108	r1m5a	762	765	777	778	783	783	790	784
n101	r1m5a	405	429	455	455	712	744		
n11	r1m5a	528							
n12	r1m5a	529	546	546	546	546	557	573	
n120	r1m5a	443	445	449					
n13	r1m5a	530	538	538	539	540			
n145	r1m3a	227							
n150	r1m2b	48	49						
n150	r1m5a	816	817	890	891	892			
n2	r1m2b	95							
n2	r1m3a	217	219	227	229	231	233		
n2	r1m4b	249							
n2	r1m5a	426	439	441	441	441	446	526	449
n20	r1m5a	497	509	523	534	562	589		
n21	r1m5a	820	822	829	841				
n22	r1m4b	252							
n3	r1m2b	96	121						
n3	r1m3a	216	218	226	226	228	232		
n3	r1m4b	250							
n3	r1m5a	439	440	441	525	541	546	547	
n30	r1m5a	647	679						
n33	r1m5a	620	655	657	673	703	705		
n36	r1m5a	621							
n39	r1m5a	674							
n4	r1m3a	215							
n4	r1m5a	423							
n47	r1m5a	642	696						
n5	r1m2b	98							
n51	r1m2b	29	30						
n51	r1m3a	183	201	201	210				
n51	r1m5a	639	640	643	694	910	914	912	924
		930	931			913			
n52	r1m5a	911	930						
n53	r1m5a	916	919	922	929	930			
n54	r1m5a	926	929						
n6	r1m2b	99							
n6	r1m5a	526	556	572	587	587			
n7	r1m2b	100	121	121					
n75	r1m5a	624	647						
n76	r1m5a	646	647	648	648	648	648	649	648
n8	r1m2b	181	121	121					
n99	r1m3a	233	234						
screen	r1m2b	100	107	124	124	124	128	124	128
		146	146	147	148				
screen	r1m4b	250	254	284	284	287	295		
start	r1m2b	95	105	119	120	124	153	126	153
		154	155						
station	r1m5a	712	744						
stop	r1m2b	114							
stop	r1m3a	189							
stop	r1m4b	262							

stop	r1m5a	543											
termc	r1m2b	96	105	111	117	120	126	123	121	124			
		132	139	154	156								
termc	r1m3a	172	186	193	194	202							
timeup	r1m2b	114											
timeup	r1m3a	189											
timeup	r1m4b	262											
timeup	r1m5a	416	544										
user	r1m2b	30											
vc	r1m5a	909											
v10	r1m5a	537	541										
v100	r1m5a	407	419	453	454								
v102	r1m5a	408	432										
v103	r1m5a	422	432										
v4	r1m2b	97											
v4	r1m4b	251											
v5	r1m5a	532	561	586	588								
y50	r1m3a	182	192	199	200								
y50	r1m5a	909	910	911									
y52	r1m3a	182	213										
y53	r1m3a	207	213										
y7	r1m5a	501	541	559	560	575						576	
y8	r1m5a	553	559	560	566	575						576	
where	r1m2b	130											
where	r1m5a	442	444										

lesson information

lesson name = cgerl

starting date = 11/20/73

last edited on 08/21/74 at 10.52.53

by neal of course eecge

at site 7, station 27

author name = J. P. Neal

department = Elec. Engg.

telephone number = 333-4351

discipline = E E

grade level = CGE authors

description of lesson = CGE-PLATO* Tests & Special Software Routines.

----- part=1, block=a -----

block 1a, cgeindexid

2 stop
 3 **** For Neal, CGERL, Room 248; EEB.

4 One line description of this lesson --

5 The Router Lesson for Courses ee244 and eecge.

6 Divisions of this Lesson:

	Block	Unit
7 Router unit	cgestart	cgestart
8 Index of cge experiments	cgeind	cgeind
9 End-exp questionnaire	questi	questi
10 Table of plato-characters	charplato	
11 Table of cge characters	charge	
12 Chars for cge character set	cgechar	
13 Common for student statistics	statlog	

14 final edit 29 aug 74 Neal.

15 *list info
 16 *list symbols
 17 *list charset, /*)
 18 *list variian,charset,cgeindex,cgechar
 19 ****
 20 start
 21 write (at,1010) Loading the CGE Character Set
 22 stop
 23 doto \$loop,n3#0,127
 24 char n3
 25 , 0,0,0,0,0,0,0,0
 26 \$loop
 27 start
 28 charset cgeindex,cgechar
 29 erase
 30 dataon
 31 ext 0

\$\$ this sequence will insert
 \$\$ blanks in all r/w charset
 \$\$ spaces before loading the
 \$\$ cge character set

----- part=1, block=b -----

block 1b, cgestart

33 unit cgestart
 34 common cgeindex,statlog,322
 35 name n2
 36 jump n2='inst',instruct,x
 37 jump user='student'\$and\$station#251,x,cgeind

38 jump user='student'\$and\$station=236,x,cgeind
39 at 1214
40 write At this time you may only have access to CGE-PLATO
41 at the CGE Research Laboratory, Room 248 EEB.
42 pause 3
43 jumpout plato
44 ***
45 unit instruct
46 at 1210
47 write One moment please
48 jumpout cgerl,instr
49 ***
50 unit cgeind3
51 next cgeind3
52 at 510
53 write You are not at the CGE station in Room 248 EEB.
54 Therefore, I will send you back to our title page.
55 pause 3
56 jumpout cge
57 at 1010
58 write Please be patient.
59 ***
60 unit cgeind4
61 jump h2='ee244',cont1,x
62 join n3=nc(nc(4)-8)\$and\$rstart1=nc(nc(4)-7),old,new,
63 * \$\$ 8,7 instead of 6,5
64 calc nc(n21)←n3
65 nc(n21+1)←rstart1
66 entry cont
67 jump resume
68 ***
69 unit cgeind2
70 at 1210
71 write You are not at the CGE Station. You will be
72 taken to Sample when you press next. Press
73 Shift-Stop if you want to leave.
74 pause
75 inhibit jumpchk
76 at 3224
77 write One Moment Please!
78 jumpout sample
79 ***
80 unit skiper
81 at 510
82 write now going to lesson CGE
83 inhibit jumpchk
84 jumpout cge

----- part=1, block=c -----

block 1c, cgeind;

86 unit cgeind
87 route and lesson, cgeind
88 route error, cgeind \$\$ specify where to go on exec. error.
89 term index
90 at 207
91 write COMPUTER-GUIDED EXPERIMENTS

92 0. An Intro. to the CGE Station Chap. 1,2,3
93 1. The Oscilloscope Chap. 9
94 2. The Audio Oscillator Chap. 13
95 3. The Function Generator Chap. 14
96 4. The DC Supply Chap. 8
97 5. The Vacuum Tube Voltmeter Chap. 4,12
98 6. Measurements of Transients Chap. 14
99 7. Measurements of Impedance Chap. 3
100 8. Two-Port Networks

101 The above experiments should be completed in sequence. Prior to attempting an experiment, you
102 should have read the above references in:

104 105 Guide to Electronic Measurements and Laboratory Practice, by S. Wolf, Prentice-Hall, 1973.

106 While in any experiment:

107 To return to this page, -TERM- index.
108 To record your comments, -TERM- comment.
109 To read tech. data and spec., -TERM- slides.

110 Select an experiment by typing its number, or
111 reenter where you shift-stopped out by pressing r.

112 arrow 3010

113 long 1

114 match n1,0,1,2,3,4,5,6,7,8,r

115 course n2

116 jump station=236\$and\$n2='ee244',cgeind2,x

117 jump station=251\$or\$n2='eecge',x,cgeind3

118 jump n1,x,cgeind1

119 judge no

120 at 3110

121 write Type the number 0,1,2 ... etc.

122 ***

123 unit cgeind1

124 course n2

125 name n3

126 calc n3&n3\$mask\$07777777777777770000

127 jump n1,x,x,x,x,x,x,x,x,cgeind4

128 jump n2#='ee244',cont,x

129 calcs n1,nc(3)+'x','eex00','eex01','eex02','eex03','eex04','eex05','eex06','eex07','eex08'

130 join n3=nc(nc(4)-8)\$and\$nc(3)=nc(nc(4)-7),old,new

REFERENCES

131 calc nc(n21)+n3
132 nc(n21+1)+nc(3)

133 entry cont
134 at 510
135 write Now going to experiment selected.
136 inhibit jumpchk
137 jumpout 'n1;x;eex#0;eex#1;eex#2;eex#3;eex#4;eex#5;eex#6;eex#7;eex#8
138 ***

139 unit old
140 calc n21+nc(4)-8 \$\$ 8 instead of 6
141 exit 1
142 ***

143 unit new
144 calc n21+nc(4)
145 nc(4)+nc(4)+8 \$\$ 8 instead of 6
146 exit 1

----- part=1, block=d -----

block 1d, quest1

148 ***** End of Experiment Questionnaire *****

149 unit quest1
150 at 810
151 write You have completed this experiment.

Please complete the following questionnaire,
in order to bring your comments to date.

Please type the number of the multiple-
choice statement below which best reflects
your present opinion.

A. I believe my last CGE experiment is worthwhile.

1. Strongly Agree
2. Agree
3. Undecided
4. Disagree
5. Strongly Disagree

158 arrow 2510
159 long 1
160 ok
161 ***

162 unit quest2
163 at 1210
164 write B. I would have learned more about the
topic of this experiment in a conventional
laboratory course.

- 172 1. Strongly Disagree
173 2. Disagree
174 3. Undecided
175 4. Agree
176 5. Strongly Agree

177 arrow 2510
178 long 1
179 ok
180 ***

181 unit quest3
182 at 810

183 write C. How would you advise a friend who
184 was considering taking a Computer-Guided
185 Experimental section of the Introductory
186 EE Laboratory course, EE244.

- 187 1. Fight tooth and nail to get into CGE.
188 2. Take the CGE section if reasonably possible.
189 3. Take the CGE section only if convenient.
190 4. Avoid the CGE section if convenient.
191 5. Avoid CGE like a plague.

192 arrow 2510
193 long 1
194 ok
195 ***

196 unit quest4
197 at 1210

198 write D. Have you previously covered the topic of your
199 last CGE experiment in any other laboratory course?

200 arrow 1640
201 long 1
202 ok

----- part=1, block=e -----

block ie, comment1

204 unit comment1
205 back cgeind
206 at 510

207 write You are invited to type any final comments you
208 care to offer!

209
210 Press -NEXT- to enter another line of comment.

211 Press -BACK- when finished.
212 calc n1+1110

213 entry comment2
214 arrow n1+n1+100
215 key back

216 ok
217 endarrow
218 goto key=next, comment2, x
219 press back

----- part=1, block=f -----

block 1f, charplato

221 *** The following PLATO character sets are in use:

222 *id Normal lower case (lc):

223 *lc1 a b c d e f g h i j k l m n o p q r s t u v w x y z
224 *lc2 0 1 2 3 4 5 6 7 8 9 = + - + x ; , . /

225 *id Normal upper case (uc):

226 *lc1 a b c d e f g h i j k l m n o p q r s t u v w x y z
227 *uc1 A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

228 *lc2 0 1 2 3 4 5 6 7 8 9 = + - + x ; , . /
229 *uc2 < > [] \$ % - ' * () Σ Δ φ u : " ! ?

230 *id MICRO then key above the character:

231 *lc1 a b c d e f g h i j k l m n o p q r s t u v w x y z
232 *char α β 8 λ μ π ρ σ θ ω

233 *lc2 0 1 2 3 4 5 6 7 8 9 = + - + x ; , . /
234 *char < > @ 7 ≠ & ~ ♦ \

235 *lc1 a b c d e f g h i j k l m n o p q r s t u v w x y z
236 *uc1 A B C D E F G H I J K L M N O P Q R S T U V W X Y Z
237 *char ← → ← → ↑ ↓

238 *lc2 0 1 2 3 4 5 6 7 8 9 = + - + x ; , . /
239 *uc2 < > [] \$ % - ' * () Σ Δ φ u : " ! ?
240 *char ≤ ≥ { } * = Δ

241 *id ACCESS then key above the char (ACCESS = shift □):

242 *lc1 a b c d e f g h i j k l m n o p q r s t u v w x y z
243 *char α β 8 λ μ π ρ σ θ ω
244 *lc2 0 1 2 3 4 5 6 7 8 9 = + - + x ; , . /
245 *char < > 2 3 4 @ 7 8 9 ≠ & ~ ♦ \

246 *lc1 a b c d e f g h i j k l m n o p q r s t u v w x y z
247 *uc1 A B C D E F G H I J K L M N O P Q R S T U V W X Y Z
248 *char ← B C → E F G H I J K L M N O P Q R S T U V ↑ ↓ Y Z

249 *lc2 0 1 2 3 4 5 6 7 8 9 = + - + x ; , . /
250 *uc2 < > [] \$ % - ' * () Σ Δ φ u : " ! ?
251 *char ≤ ≥ { } * % - ' * (≈ Σ Δ φ : " ! ?

252 *** End of PLATO Character listings.

----- part=1, block=g -----

block 1g, charge:

254 *** The following characters are in the CGE Character Set:

255 *id FONT then key above the char (FONT = shift MICRO):

256 ** Position numbers of cge characters (read down):

257 * 1 2 3 4 5 6 7 8 9 1 1 1 1 1 1 1 1 1 1 1 1 2 2 2 2 2 2 2
258 * 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6

259 *lc1 a b c d e f g h i j k l m n o p q r s t u v w x y z

260 *char / \ ^ _ { } [] . , ; ! ? * < > { } [] ^ _ { }

261 ** Position numbers of cge characters (read down):

262 * 2 2 2 3 3 3 3 3 3 3 4 3 5 3 4 5 5 6 6 4
263 * 7 8 9 0 1 2 3 4 5 6 4 7 3 8 8 2 9 1 2 0

264 *lc2 @ 1 2 3 4 5 6 7 8 9 = + - + x ; , . /

265 *char ~ + -

266 ** Position numbers of cge characters (read down):

267 * 6 6 6 6 6 7 7 7 7 7 7 7 7 7 7 7 8 6 8 8 8 8 8 8 8 8 9
268 * 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0

269 *lc1 a b c d e f g h i j k l m n o p q r s t u v w x y z

270 *uc1 A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

271 *char | + € ¥ ~ { } σ [L]] > ◊

272 ** Position numbers of cge characters (read down):

273 * 1
274 * 9 9 9 9 9 9 9 9 9 0 0 0 0 0 1 1 2 6 2 0
275 * 1 2 3 4 5 6 7 8 9 0 8 1 2 2 6 3 0 4 4

276 *lc2 @ 1 2 3 4 5 6 7 8 9 = + - + x ; , . /

277 *uc2 < > [] \$ % _ ' * () Σ Δ ∫ ∂ ∙ ∙ ∙ ∙ ∙ ∙ ∙

278 *char ∙

279 *id FONT then shift □ then key above the character:

280 *** Position numbers of cge characters (read down):

281 * 3 4 4 4 4 4 4 4 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5
282 * 9 1 2 3 5 6 7 9 0 1 4 5 6 7 8

283 *lc1 a b c d e f g h i j k l m n o

284 *char □

285 ** Position numbers of cge characters (read down):

286 * 1 1 1 1 1 1 1 1 1 1 1 1 1
287 * 0 0 0 0 1 1 1 1 1 2 2 2
288 * 3 5 6 7 9 0 1 3 4 5 8 9 0 1 2

289 *ic1 a b c d e f g h i j k l m n o

290 *uc1 A B C D E F G H I J K L M N O

291 *char

292 *** End of CGE Character Listings.

cgeind	cgeind	86	37	38	87	88	285
cgeind1	cgeind	123	118				
cgeind2	cgestart	69	116				
cgeind3	cgestart	50	51	117			
cgeind4	cgestart	60	127				
cgestart	cgestart	83					
comment1	comment1	204					
comment2	comment1	213	218				
cont	cgeind	133	128				
cont1	cgestart	66	61				
instruct	cgestart	45	36				
new	cgeind	143	62	130			
old	cgeind	139	62	130			
quest1	quest1	149					
quest2	quest1	167					
quest3	quest1	181					
quest4	quest1	196					
skipper	cgestart	80					
back		219					
key		218					
inc		62	62	62	62	64	130
		130	130	130	131	132	145
		145					132
next		218					144
n1		114	118	127	129	212	214
n2		35	36	61	115	116	117
n2t		64	65	131	132	140	128
n3		23	24	62	64	125	126
rstart1		62	65			130	131
station		37	38	116	117	126	127
user		37	38				

lesson information

lesson name = cgeindex

starting date = 01/29/73

last edited on 09/03/74 at 11.28.26

by neal of course eecge

at site 7, station 27

author name = J.P. Neal

department = EE

telephone number = 333-4351

discipline = EE

grade level = Freshman

description of lesson = The Router Lesson ~~for Courses ee244 and ee245~~

lesson eex00 at 5:11 am on friday, september 6, 1974

----- part=1, block=a -----

block 1a, eex00id

2 stop
3 sys For Neal, CGERL, Room 248, EEB.

4 One line description of this lesson --

5 An Introduction to the CGE Station.

Divisions of this Lesson: Block Unit

Id for this file	eex00id
Experiment eex00:	
Description of cge station	x00m0a
Inclusion	x00m0a
See s.r. and terms	x00m1a
	ch1-ch6

Final edit 29 aug 74 neal.

17 *set info
18 *list symbols
19 *edit variant,charset,cgeindex,cgechar
20 *new
21 start
22 finish endunit
23 while 1,100 Loading the CGE Character Set
24 charset,variant,cgechar
25 *edit
26 title
27 message 100-200
28 next

----- part=1, block=b -----

block 1b, x00m0a

26 unit x00m0a
27 erase
28 name n2
29 next x00m0a1
30 help x00m0a
31 calc n10=400,n30=400,0
32 jump n10=4000,x00m0a1,x
33 *end n 0
34 at
35 write Hello (a,n2)

36 This PLATO terminal is externally interfaced with the

37 adjoining electronic experimentation equipment.

38 At this CGE-PLATO station, PLATO can automatically
39 determine the external interconnections between terminals
40 of the experimentation equipment or check the settings
41 of the dials on that equipment.

42 This lesson will acquaint you with the uses of PLATO and
43 the names of the panel controls and terminals of the
44 instruments and circuit boards of the CGE station.

45 Subsequent experiments will guide you to learn worthwhile
46 methods for operating the electronic instruments and making
47 electronic measurements.

48 Experienced instructors have programmed connection
49 checks and dial checks where necessary to sense your
50 progress through the experiments and to provide you
51 with additional assistance, if you seem to encounter
52 undue difficulty or request help or information.

53 If you are unacquainted with PLATO, press -HELP-,
54 otherwise, press -NEXT-.

55 ***

56 unit >00mRa1
57 back >00mRa
58 next >00mRa2
59 zero n30
60 at 1210

61 write If you want to see a sample of the
62 variety of lessons now programmed on PLATO,
63 -TERM1- sample. Otherwise, press -NEXT-.

64 ***
65 unit >00mRa2
66 back >00mRa1
67 next >00mRa
68 at 503

69 write Now that you are acquainted with the Plato operation, you
70 are ready to proceed with the Computer Guided Experiments.

71 If you are somewhat familiar with electronic instruments
72 or are exceptionally alert, you will find that you can
73 rapidly accomplish the sequential learning tasks presented
74 to you in the subsequent experiments.

75 Do not be dismayed if you encounter difficulties. If you
76 have no difficulties and breeze through the tasks presented
77 to you, you may be learning very little.

78 As Alice in Wonderland said,
79 "Oh, a knot? Do let's untie it!"

----- part=1, block=c -----

block 1c, x00mab

```
81 unit x00mab
82 back x00mab
83 next x00mab1
84 name n2
85 at 905
86 write Hello again (a,n2)
```

87 After this brief introduction you should be able to
88 communicate with me and set the instruments in the
89 "safe initial mode". This initial mode is specified
90 and rechecked whenever you start a new experiment.

91 ***

```
92 unit x00mab1
93 back x00mab
94 next x00mabC
95 at 907
```

96 write In front of you are five rack-mounted electronic
97 instruments.

98 Each instrument has a number of terminals between
99 which you can make interconnections, and a number of
100 knobs, switches, and dials by which you can adjust
101 the instruments.

102 I will list the names we use to refer to each of
103 the instruments, terminals, and dials, and I suggest
104 you locate each of them on the instrument panels.

105 ***

```
106 unit x00mabC
107 back x00mab1
108 next x00mabC1
109 at 510
```

110 write At the top left of the equipment rack is the
111 Analab DUAL-TRACE SCOPE Type 1120. Note that red
112 labels pertain to red knobs, and black labels
113 pertain to black dials.

114 Important dials of the SCOPE are:

115 BEAM FINDER (a black dial)	SCALE
116 INTENSITY (a red knob)	FOCUS
117 A & B SEPARATION	Power
118 Y DISPLAY	X DISPLAY
119 Y POSITION	X POSITION
120 ***	

```
121 unit x00mabC1
122 back x00mabC
123 next x00mabD
124 at 506
```

125 write To the right of the SCOPE, in the same frame,

126 is the Analab TYPE 700 PLUG-IN.

127 Important dials of the PLUG-IN are:

128 A VOLTS TIME B VOLTS

129 NULLs (red knobs)

130 A PREAMP TRIGGER SOURCE SWEEP MODE B PREAMP

131 TRIGGER SLOPE

132 Important terminals of the PLUG-IN are:

133 A INPUT TRIGGER INPUT B INPUT

part=1, block=d

block 1d, xferred

135 unit xferred

136 back xferred1

137 next xferred1

138 at

139 write Directly below the SCOPE and the PLUG-IN is the
140 FLUCTION GENERATOR:

141 On the FNU. GEN. there are:

	Dials	Terminals
143	TRIGGER	SQUARE
144	MULTIPLIER	TRIANGLE
145	CYCLES/SEC.	SINE
146	OUTPUT (black knob)	RAMP
147	AMPLITUDE (red knob)	OUTPUT (red terminal)
148	DC LEVEL	TRIG OUT
149	***	

150 unit xferred1

151 back xferred1

152 next xferred1

153 at

154 write Directly to the right of the PLUG-IN is
155 the AUDIO OSCILLATOR.

156 The dials of the AUD. OSC. are:

157 POWER, Frequency, and AMPLITUDE. The frequency dial
158 is the large one in the center.

159 The terminals of the AUD. OSC. are:

160 GROUND (black), and the left and right red OUTPUT
161 terminals.

162 ***

163 unit $\times 00m0e$
164 back $\times 00m0d1$
165 next $\times 00m0e1$
166 at 807

167 write Next to the AUD. OSC. is the VACUUM TUBE VOLTMETER.

168 The RANGE dial is the only dial of the VTVM.

169 INPUT terminals of the VTVM are red and black.

170 OUTPUT terminals of the VTVM are red and black.

171 In each case here, the black terminals are GROUND.

172 ***

173 unit $\times 00m0e1$
174 back $\times 00m0e$
175 next $\times 00m0g$
176 at 807

177 write The CONSTANT VOLTAGE, CONSTANT CURRENT or
178 DC SUPPLY is located below the AUD. OSC. and the VTVM.

179 The dials of the DC SUP. are:

180 METER, VOLTAGE, and CURRENT.

181 The terminals of the DC SUP. are:

182 + (red), - (black), and GROUND.

183 Incidentally, the ground terminals of all of the
184 instruments are interconnected at the power receptacles,
185 so GROUND is essentially only one common terminal.

----- part=1, block=e -----

block i.e., $\times 00m0g$

187 unit $\times 00m0g$
188 back $\times 00m0e1$
189 next $\times 00m0h$
190 lab $\times 00s0b$
191 at 807
192 write The CGE-PLATO system has the capability of

193 automatically checking the interconnections between
194 30 terminals and automatically checking the settings
195 of 12 dials on the experimentation equipment.

197 If you want to see a record of a present check,
198 press -LAB-.

199 Otherwise, press -NEXT-.

200 ***

201 unit x00msh
202 join inmodia
203 entry icheck
204 join tnmdeck
205 jump n17, icheck, x00mia
206 ***

207 unit x00mia
208 back x00mifl
209 next x00mifb
210 name nt
211 at n17
212 write Hello again (a,n2)

213 At any time during an experiment, you can reach a
214 slide display showing descriptions of the purposes of
215 the important dials and terminals, the manufacturer's
216 specifications for the instruments, and other generally
217 useful information by the -TERM- slides.

218 You can do the experiments listed later in any order.

219 Consequently, if you attempt to perform the
220 experiments out-of-sequence, and encounter too
221 much difficulty, you may be automatically
222 caused to stop your selected experiment and
223 complete a prior-listed experiment, in order for
224 you to learn how to properly use an instrument.

----- part=1, block=f -----

block if, x00end

226 unit x00m1b
227 next x00end
228 back x00mia
229 at n19
230 write You are now ready to explore physical reality.
Using this Computer-Guided Experimentation
station.

231
232 Leave all dials and connections in the safe
initial mode. Then press -NEXT- to go to the

Index of Experiments.

236 ***

```
237 unit    x0050fa
238 calc   ' n254'ee0x00'
239          n2640
240          n304400
241 join   jmpmes
242 jumpout help
243 end   .
244 ***
```

245-	unit	x00sib
246	base	
247	back	x00mig
248	next	x00sdc
249	join	r1m2b
250	***	

```

251 unit    x000000c *
252 back   x000000b
253 next   x000000h
254 join   rlm4b
255 ***
```

256	unit	x@blend
257	course	n?
258	calcc	n? = 'ee
259	:	na(n2)
260	:	na(n2)
261	course	n1
262	join	n1 = 'ee
263	join	imp'més
264	jumpout	egeind

```
266 unit endunit
267 source n2
268 jump n2#`ee244', leave,x
269 calc nc(n2+7) enc(n2+7)+ahelp
270 " vc(n2+1+6) +vc(n2+1+6) +atime/600000
```

271 entry leave
272 ***gives this lesson use of talk routines on cgerl

273 use rger1,rlm4b
274 use rlm4c
275 use rlm2b

part=1, block=g

block 1g, ckl

277 unit +cc
278 common ageindex,statlog,322

```

279 define ckc
280     cc=o40
281     authrc=n33
282     codata=p30
283     bestcod=n36      $$ author code for best match
284     besterr=n39      $$ number of errors in best match
285     segment,acode=authrc,6
286     segment,ccode=codata,6
287     errors=n47
288     print=n49      -$$ -1=print off   0=print on
289     start=n1
290     search=n2
291     termo=n3
292     keytim=v4,
293     dntac=n5
294     count=n6
295     acod1=n4
296     acod2=n5
297     ecod1=n6
298     ecod2=n7
299     state=n8

300 unit ckow
301 erase
302 calc print+0
303 goto cc1

304 unit ckc
305 calc print+1
306 goto cc1

307 unit ckci
308 calc print+1
309 goto cc3

310 unit wckciw
311 erase
312 calc print+0
313 goto cc3

314 unit cc1
315 *** Data Collection Routine. ****
316 calc n22+nci+1
317     n23+1
318 mode rewrite
319 dr oness
320 mode write
321 pack codata,+++++*****+
322 calc start+termo+1
323 keytime=clock
324 counted
325 time
326 enable
327 ext cc+termo

328 entry cc1a
329 pause

```

```

330 goto (key=timeup) - (key=micro$and$user='author'),cc1b,x,cc1out
331 goto (key$mask$010000)=0,cc1a,x $$ throw out keyboard key
332 calc keytime=clock
333 datac$key$mask$037
334 count=count+1
335 calc termc=0,termc+1,termc+termc $$stops array error
336 * when hardware not turned on
337 goto (datac=start) - (count>31),cc1c,x,cc1e
338 calc ccode(termc)+start
339 termc+datac
340 ext cc+termc
341 goto cc1a

342 unit cc1c
343 calc ccode(termc)+0
344 goto termc=start,cc1d,x
345 calc ccode(termc)+start
346 goto cc1d

347 unit cc1d
348 calc start+start+1
349 datac+ccode(start)
350 goto ((datac+"")$and$(start$30)) - (start>30),cc1d,x,cc2
351 calc termc=start
352 ext cc+termc
353 goto cc1a

354 unit cc1b
355 time 1
356 goto clock-keytim>1.5;x,cc1a
357 calc keytime=clock
358 ext cc+termc
359 goto cc1a

360 unit cc1e
361 * Error if more than 30 keys received!! rewrite
362 mode 3123
363 at
364 write An Error Has Occurred!

365 unit cc1out
366 calc n22+nclient-1
367 pack authrc,+++++,
368 goto cc2

369 unit cc2
370 ext 0
371 disable
372 calc besterr+100 $$init errors
373 mode erase
374 do ccmess
375 mode write
376 goto cc3

377 unit cc3
378 calc errors+0
379 start+termc+0

```

```

380 do cc4
381 goto n23<0,x,skipc
382 goto nc(322)<0,skipc,x
383 goto n21<5$or$n21>310,skipc,x
384 calc nc(n21+4)←nc(n21+4)+1
385 calc n47<0,nc(n21+5)←nc(n21+5)+1,nc(n21+5)←nc(n21+5)
386 zero n23
387 entry skipc
388 do besterr+errors-1,x,cc9
389 exit -print
390 do nc8
391 exit

```

----- part=1, block=h -----

Block 1h, ck2.

```

393 unit ckc2w
394 erase
395 calc print#0
396 block bestcod,authorc,3
397 write cc3
398 unit ckc2
399 on 1c print#-1
400 block bestcod,authorc,3
401 write bc3
402 unit cc4
403 calc print#0 print#1 "$$dummy calc to enter loop
404 1 start=start+1 $$next terminal number
405 branch start>30,4,x $$branch out when done
406 <ccod1←ccode(start) $$get cc code
407 <acod1←acode(start) $$get author code
408 <state (ccod1=0$and$acod1="") $or$(acod1="+")
409 branch state,1,x
410 search←start $$set search at present terminal
411 2 search=search+1 $$increment term. num.
412 branch search>30,1,x $$go away if too big
413 <ccod2←ccode(search) $$get cc code
414 <acod2←acode(search) $$get authors code
415 states (acod1=acod2$and$acod1!="")
416 <state=state-2 (ccod1=ccod2$and$ccod1!=0)-4 (acod2="+")
417 branch state,x,2,2,x,2
418 errors+errors-1 $$add 1 to number of errors
419 branch print,1,x
420 4 print#0 print#1 "$$dummy calc to exit loop
421 goto start>30,-2 ((errors<-6)$and$print=0),cc5,x,cc6
422 at 1000 errors
423 calc term←start
424 do cc7
425 until cc state, should be connected to ,*** man you are in trouble ***,
        shouldn't be connected to ,

```

```

427 calc termc$search
428 do cc7
429 goto cc4
430 unit cc5
431 exit 1
432 unit cc6
433 calc errors$=7
434 at 521-200*errors
435 write *** AND MORE ***
436 exit 1
437 unit cc7
438 writetec termc,-,$,Term. 1,Term. 2,Term. 3,Term. 4,Term. 5,
439 Term. 6,Term. 7,Term. 8,Term. 9,Term. 10,
440 Term. 11,Term. 12,Ground,Term. 14,Term. 15,
441 Scope: A volts,Scope: B volts,Scope: trigger,
442 Fun-gen: sq. wave output,Fun-gen: triangle,
443 Fun-gen: sine output,Fun-gen: ramp output,
444 Fun-gen: attn'd output,Fun-gen: trigger out,
445 DC supply:(+),DC supply(-),
446 Aud-osc: right output,Aud-osc: left output,
447 VTVM: input,VTVM: output,
448 unit cc8
449 at 711-200n47
450 writetec errors,*** WIRING ERRORS *** (Press -NEXT-),
451 exit 1
452 unit cc9
453 block authorc,bestcod,3
454 calc besterr$=errors
455 unit roomess
456 at 3219
457 write CONNECTION CHECK IN PROGRESS

```

part=i, block=i -----

block 1i,* ck3

```

459 unit +dc
460 define ckd
461 dc=0100
462 authorc=n33
463 dodata=n30
464 bestcod=q39   $$ author code for best match
465 besterr=n14   $$ number of errors in best match
466 segment,acode=authorc,6
467 segment,dcode=dodata,6
468 errors=n47   $$ errors= -(number of errors found)
469 print=n49    $$ -1=print off  0=print on
470 dial=n1

```

471 keytimev2
472 match=n3
473 acod=n4
474 dcod=n5
475 imb=n16
476 cannot=n17
477 acodh=n18
478 dcod1=n19
479 state=n6
480 paren=n7
481 searching
482 screen=n9

483 unit ckd1
484 erase
485 calc
486 goto
487 unit ckd
488 calc print=-1
489 goto do

490 unit ckd1
491 calc print=-1
492 goto do

493 unit ckd1w
494 calc print
495 erase
496 goto do

497 unit ckd2w
498 erase
499 block bestcod,authorc,6
500 calc print=-1
501 goto do

502 unit ckd?
503 block bestcod,authorc,6
504 calc print=-1
505 goto do

506 unit do
507 calc n22+n24+n2+1
508 n23=1
509 rewrite
510 do
511 calc
512
513 time
514 enable
515 ext do+dial
516 entry do
517 pause
518 goto
519 goto

(key=timeup) - (key=micro\$and\$user='author'),dcfa,x,dcout
(key\$mask\$010000)=0,dcf,x \$throw out keyboard keys

```

520 calc dcode(dial) ekey$mask$077
521 dial+dial+1
522 keytime+clock
523 goto dial>2,dcdb,x
524 ext dc+dial
525 goto dcl
526 unit dcda
527 time 1
528 goto clock-keytim<1.5,dcdb,x
529 calc keytime+clock
530 ext dc+dial
531 goto dcl
532 unit dcdb
533 disable
534 ext b
535 mode erase
536 do elements
537 mode write
538 calc kesterne+1000 $$ init no. of errors in best match
539 goto dccl
540 unit dcout,
541 calc n22+nc2+nc2-1
542 push authrc, ++++++
543 calc n36+n37+n38+n39 $$ fill out rest of authrc with blank
544 goto dcdb
545 unit dcj
546 calc dial+search+parent+errors+0
547 screen#310.
548 do dc?
549 unit n23@0,x,skipd
550 do n22@1,x,skipd,x
551 calc n21+5$or$bn21>31@,skipd,x
552 calc n21+1+21+n21+n21+2)+1
553 calc n47@0,n2c(n21+3)+nc(n21+f3)+1,nc(n21+3)+nc(n21+3)
554 calc
555 entry skipd
556 do kesterne+errors-1,x,dc5
557 unit t+1/print-0)
558 unit 1
559 unit dc3
560 nt set een-1
561 write These/dials are incorrectly set
562 draw 202;1249
563 calc screen+screen+300

```

~~part=1, block=j, -----,-----~~

block in, like

```

565 unit dc2
566 calc print$print    $$dummy calc to enter loop
567 1 dial+dial+1
568 matches0    $$ set no match found yet flag
569 branch dial>22,999,x
570 decode+decode(dial)
571 1000 search+search+1      $$ incr author loc.
572 <cod>+decode(search)      $$ get author code
573 stateq(acod=("(")-(acod=""))-2(acod="+")-3(acod+"<")-4(acod">")
574 branch state, 4000,x, 300,1,600,500
575 branch carpet, 700,x
576 matchesmatch+decode+decode      $$ check for match
577 branch paren, 1000,x      $$ branch for paren loop
578 branch match, 1,000      $$ was there a match?
579 branch clear, 1000,x      $$ clear paren loop flag
580 branch match, 1,400      $$ was there a match?
581 paren-1      $$ set paren loop flag
582 branch 1000      $$ go look at next author code
583 500
584 branch match, 1,000
585 600
586 700
587 800
588 900
589 1000
590 1100
591 1200
592 1300
593 1400
594 1500
595 1600
596 1700
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598 1900
599 2000
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1578 99900
1579 100000

```

619 unit dcs
620 block authorc,bestcod,6
621 calc besterreabs(errors)

622 unit dcmess
623 at 1023
624 write DIAL CHECK IN PROGRESS

----- part=1, block=k -----

block 1k, ck5

626 unit comment
627 term comment
628 dataon
629 erase
630 at 510
631 write Please type your comment at the arrow.
632
633 Press -NEXT- to enter another line of comment.
634 Press -BACK- when finished.
635 calc nt!1110

636 entry comment1
637 arrow nt!n!+100
638 ikey back
639 nt!
640 <ndarrow
641 zoto key=next,comment1,x
642 press back

643 unit sample
644 term sample
645 at 710
646 write Now returning you to SAMPLE!
647 inhibit jumpchk
648 jumpout sample

649 unit cgerl
650 term cgerl
651 do jmpmes
652 jumpout cgerl

653 unit index
654 term index
655 do jmpmes
656 jumpout cgeindex,cgeind

657 unit jmpmes
658 write (at,1516)One moment please
659 inhibit jumpchk

660 unit commandck
661 pack n37,++fhet+a+++a(abcd)+a(ab) a++1

662 join okd
663 join n47,inmode,x
664 join n47,x,inmodec

665 unit inmodec
666 pack n42,00000000000000000000000000000000
667 join okw
668 join n47,inmodep,x

669 unit inmodep
670 pause .5
671 pause

672 unit inmode

673 engine 1210

674 unit
675 join The equipment was not set in the initial mode.

676 pause 1.5

677 pause

678 entry inmode1

679 term inmode

680 at 100

681 pause Please Remove all plugged-in connections

682 pause Securely fasten all ground links

683 pause Set the dials in this safe initial mode:

684 SCOPe:

685 INTENsITY fully CCW

686 PLUG-IN:

687 NULLS at zero

688 A and B PREAMPS OFF

689 TRIGGER SOURCE OFF

690 GATED MODE OFF

691 FUN GEN:

692 TRIGGER INT

693 HORIZONTAL fully CCW

694 DC LEVEL CCW and click

695 AUD OSC:

696 AMPLITUDE zero

697 DC SUPPLY:

698 VOLTAGE 0

699 CURRENT 0

700 VTVM:

701 RANGE 300

702 ALL POWER SWITCHES ON

703 When ready to proceed, press 'INIT'.

704 pause .5

705 end

786 unit imode
787 erase
788 at 1007
789 write Before proceeding, please return the equipment to
790 the Safe Initial Mode.
791 pause
792 join immodeck
793 exit

-- part=1, block=1 -----

block 11, ck6

715 unit slides
716 next slide1
717 term slides
718 erase
719 calcc (station=251),n101+256,256
720 slide n101
721 at 207
722 write SLIDE NO. CGE SLIDE

723 1 CGERL Entrance
724 2 The EE244 Laboratory
725 3 The CGE-PLATO System Description
726 4 Orientation of the CGE Station
727 5 Layout of Sensed Dials and Terminals
728 6 List of Sensed Dials and Terminals
729 19 Resistor Color Code
730 20 - 21 E E Symbols and Units
731 22 Recommended Unit Prefixes
732 23 Defined Physical Values
733 24 - 26 Physical Constants
734 27 - 32 SCOPE - Use of Dials and Terminals
735 33 - 35 SCOPE - Manufacturer's Specifications
736 36 - 44 PLUG-IN - Use of Dials and Terminals
737 45 - 50 PLUG-IN - Manufacturer's Specifications
738 51 - 53 FUN.GEN. - Use of Dials and Terminals
739 54 - 56 FUN.GEN. - Manufacturer's Specifications
740 57 - 60 AUD.OPT. - Use of Dials and Terminals
741 61 - 63 FUN.TEMP. - Manufacturer's Specifications
742 64 - 66 VTVM - Use of Dials and Terminals
743 67 - 68 VTVM - Manufacturer's Specifications
744 69 - 71 DC SUPP - Use of Dials and Terminals
745 72 - 75 DC SUPP - Manufacturer's Specifications
746 76 Graph of a Transient
747 79 CGE-PLATO Interface.

748 Type slide no. ,press -NEXT-, or -BACK- to return.
749 arrow 1021
750 store n100
751 ok
752 brack
753 goto (n100<96),slide1,slideno

754 ***

755 unit slides
756 back slides
757 next slides
758 set 1210
759 write 101 Type a number less than 96.
760 ***

761 unit slides
762 slide n100+12
763 ***

764 unit slides
765 back slides
766 next slides
767 set 1210
768 write This is slide {z,n100}. Press -NEXT- for next slide
769 slide n100
770 ***

771 unit slides
772 back slides
773 next slides
774 calc n100+n100+1
775 write n100+96,slide1,x
776 slide n100
777 set 1210
778 write You can't show a slide greater than 96.

comm	455	319	374			
tel	314	303	306			
calca	328	331	341	353	356	359
calcb	354	338				
calc	345	337				
calc1	347	344	346	350		
calc2	360	357				
calc3	365	358				
calc4	369	368				
calc5	372	369	376	397		401
calc6	373	370	429			
calc7	375	421				
calc8	377	421				
calc9	378	424	428			
calc10	380	390				
calc11	442	360				
calc12	443	360				
calc13	444	360				
calc14	445	360				
calc15	446	360				
calc16	447	360				
calc17	448	360				
calc18	449	360				
calc19	450	360				
calc20	451	360				
calc21	452	360				
calc22	453	360				
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calc26	457	360				
calc27	458	360				
calc28	459	360				
calc29	460	360				
calc30	461	360				
calc31	462	360				
calc32	463	360				
calc33	464	360				
calc34	465	360				
calc35	466	360				
calc36	467	360				
calc37	468	360				
calc38	469	360				
calc39	470	360				
calc40	471	360				
calc41	472	360				
calc42	473	360				
calc43	474	360				
calc44	475	360				
calc45	476	360				
calc46	477	360				
calc47	478	360				
calc48	479	360				
calc49	480	360				
calc50	481	360				
calc51	482	360				
calc52	483	360				
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calc59	490	360				
calc60	491	360				
calc61	492	360				
calc62	493	360				
calc63	494	360				
calc64	495	360				
calc65	496	360				
calc66	497	360				
calc67	498	360				
calc68	499	360				
calc69	500	360				
calc70	501	360				
calc71	502	360				
calc72	503	360				
calc73	504	360				
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calc100	531	360				
calc101	532	360				
calc102	533	360				
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calc104	535	360				
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calc106	537	360				
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calc110	541	360				
calc111	542	360				
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calc136	567	360				
calc137	568	360				
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calc141	572	360				
calc142	573	360				
calc143	574	360				
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calc145	576	360				
calc146	577	360				
calc147	578	360				
calc148	579	360				
calc149	580	360				
calc150	581	360				
calc151	582	360				
calc152	583	360				
calc153	584	360				
calc154	585	360				
calc155	586	360				
calc156	587	360				
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calc158	589	360				
calc159	590	360				
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calc162	593	360				
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calc187	618	360				
calc188	619	360				
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calc190	621	360				
calc191	622	360				
calc192	623	360				
calc193	624	360				
calc194	625	360				
calc195	626	360				
calc196	627	360				
calc197	628	360				
calc198	629	360				
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calc200	631	360				
calc201	632	360				
calc202	633	360				
calc203	634	360				
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calc230	661	360				
calc231	662	360				
calc232	663	360				
calc233	664	360				
calc234	665	360				
calc235	666	360				
calc236	667	360				
calc237	668	360				
calc238	669	360				
calc239	670	360				
calc240	671	360		</		

ckd2w	ck3	497				
comment,	ck5	626				
comment1	ok5	636	641			
dc	ok3	506	486	489		
dcmess	ok4	622	510	536		
dcout	ok3	540	518			
dcv8	ok3	516	519	525	528	531
dcv8a	ok3	526	518			
dcv8b	ok3	532	523	544		
dcv8c	ok3	545	492	496	501	505
dc2	ok4	569	548	615		
dc3	ok3	559	599			
dc4	ok4	616	600			
dc5	ok4	619	55			
endunit	*okend	266	18	262		
icheck	*okcheck	203	205			
imodel	ok5	706				
index	ok5	653				
inmode	ok5	672	663			
inmodel	ok5	665	664			
inmodeck	ok5	668	204	712		
innodep	ok5	669	668			
inmodel	ok5	678	202			
jmpmes	ok5	657	241	263	651	655
leave	*okend	271	268			
r1m2b			249			
r1m4b			254			
sample	ok5	643				
skip4	ok1	367	381	382	383	
skipd	ok3	555	549	550	551	
slideno	ok6	755	753			
sliders	ok6	715	756	757	765	772
slide1	ok6	764	716	753	775	773
slide2	ok6	771	766			
slide3	ok6	761				
*okend	*okend	256	227			
*okinit	*okinit	136	57	82		
*okinit1	*okinit	56	29	32	66	
*okinit2	*okinit	65	56			
*okinit3	*okinit	81	62	93		
*okinit4	*okinit	92	83	107		
*okinit5	*okinit	106	94	122		
*okinit6	*okinit	121	108	136		
*okinit7	*okinit	135	123	151		
*okinit8	*okinit	150	137	154		
*okinit9	*okinit	163	152	174		
*okinit10	*okinit	173	165	188		
*okinit11	*okinit	187	175	247		
*okinit12	*okinit	201	189	208	253	
*okinit13	*okinit	207	205	228		
*okinit14	*okinit	216	209			
*okinit15	*okend	237	38			
*okinit16	*okend	245	190	252		
*okinit17	*okend	251	243			
+dc	ok1	277				
+dc	ok1	467				
abs	okd	621				

acod	ckd	479	572	573	573	573	573	573	573	573	573
acode	ckd	485	407	414							
acode	ckd	466	572	591							
acost	ckd	395	407	408	408	415	415	415			
acodi	ckd	477	591	592	592	593	593				
acodis	ckd	396	414	415	416						
ahelp	ckd	369									
atime	ckd	370									
authore	ckd	281	285	367	396	400	453				
authore	ckd	462	466	470	503	542	620				
bark	ckd	642									
badblood	ckd	383	396	469	453						
baulcon	ckd	364	409	507	620						
besterr	ckd	384	372	393	454						
besterr	ckd	4465	530	606	621						
bewig	ckd	426	575	583	585						
cc	ckd	280	327	346	352	358					
codata	ckd	282	286	321							
ccode	ckd	286	338	343	345	349	406	413			
coedi	ckd	341	406	460	416	416					
coedt	ckd	398	411	416							
clock	ckd	323	332	356	357						
clerk	ckd	512	520	528	529						
count	ckd	294	324	334	334	337					
cuban	ckd	293	303	337	339	349	350				
de	ckd	461	515	524	530						
decata	ckd	463	467								
dead	ckd	424	520	526	593						
dearie	ckd	462	520	520	567						
dearli	ckd	473	582	593							
dearl	ckd	510	511	515	520	521	523	534			
dearl	ckd	540	567	567	569	570	586	586	598		
dearl	ckd	601	606								
errors	ckd	392	370	398	418	418	421	422	434		
errors	ckd	471									
emb	ckd	410	506	556	595	595	621				
env	ckd	420	500	500	504						
env	ckd	511	511	519	520	641					
entitum	ckd	320	321	322	356	357					
eytum	ckd	471	512	522	528	529					
match	ckd	371	561	576	576	578	580	584	593		
metre	ckd	329	329	339							
metre	ckd	512									
no	ckd	256	259	260	260	269	269	382	384		
no	ckd	310	355	385	385						
no1	ckd	550	562	562	563	553	553				
no2	ckd	516	316	366	366						
no3	ckd	507	507	541	541						
no4	ckd	641									
ni	ckd	361	262	269							
ni	ckd	470	605	637	637						
nir	ckd	750	743	763	768	769	774	774			
nir1	ckd	710	716								
nir2	ckd	475									
nir3	ckd	476									
nir4	ckd	477									

n19	ckd	478							
n2	ckc	30	35	84	86	210	212	257	267
		268	298						
n21	ckc	259	259	260	260	269	269	270	383
		383	384	384	385	385	385	385	
n21	ckd	541	551	552	552	553	553	553	553
n22	ckc	316	366						
n22	ckd	507	541						
n23	ckc	317	381	386					
n23	ckd	598	549	554					
n25	ckc	238							
n26	ckc	239							
n3	ckc	291							
n3	ckd	472							
n34	ckc	31	31	32	33	59	240	282	
n34	ckd	463							
n33	ckc	281							
n33	ckd	461	661	666					
n36	ckc	283							
n36	ckd	543							
n37	ckd	543							
n38	ckd	541							
n39	ckc	284							
n39	ckd	464							
n4	ckc	295							
n4	ckd	473							
n44	ckd	465							
n47	ckc	287	385	449					
n47	ckd	468	553	663	664	668			
n49	ckc	288							
n49	ckd	469							
n5	ckc	293	296						
n5	ckd	474							
n6	ckc	294	297						
n6	ckd	474							
n7	ckc	298							
n7	ckd	480							
n8	ckc	299							
n8	ckd	481							
n9	ckd	483							
paren	ckd	488	546	577	579	581			
print	ckc	388	382	385	388	312	389	395	483
print	ckd	483	419	420	420	421			
print	ckd	469	485	488	491	494	588	584	566
screen	ckd	566	596	597	597				
search	ckc	482	547	560	563	563	599	600	614
search	ckd	490	410	411	411	412	413	414	
segment	ckc	481	546	571	571	572	590		
segment	ckd	285	286						
start	ckc	466	467						
start	ckc	289	322	337	338	344	345	348	349
state	ckc	398	358	351	379	404	404	405	407
state	ckd	410	421	423					
station	ckd	479	573	574					
station	ckd	719							

term	ckc	291	322	327	335	335	335	335	334
		348	343	344	345	351	352	358	423
		427	428						
timeup	ckc	338							
timrmp	ckd	518							
user	ckc	338							
user	ckd	518							
vo	ckc	270	270						
vo	ckd	471							
vy	ckc	292							

lesson information

lesson name = eex800

starting date = 10/07/72

last edited on 09/05/74 at 18.56.55

by birth of course eedge

at site 7, station 27

author name = J P Neal

department = EE

telephone number = 333-4351

discipline = elect. engr. lab

grade level = Freshman

description of lesson = An Introduction to the CGE Station

lesson eex01 at 2:23 am on tuesday, august 27, 1974

part=1, block=a

block 1a, eex01id

2 stop
3 **** For Neal, CGERL, Room 248, EEB.

4 One line description of this lesson --

5 The Operation and Uses of the Oscilloscope, Analab 1120.

6	Divisions of this Lesson:	Block	Unit
7	Id for this file	eex01id	
8	Experiment eex01;		
9	Objectives	x01m0a	x01m0a
10	Find crt spot	x01m1a	x01m1a
11	Measure constant v	x01m2a	x01m2a
12	Measure v	x01m3a	x01m3a
13	Use null dials	x01m4a	x01m4a
14	Display 2 voltages	x01m5a	x01m5a
15	Lissajous figure	x01m5a	x01m6a
16	Final test	x01m7a	x01m7a

17 final edit 21 aug 74 neal.

18 *list info
19 *list symbols
20 *list variyan,charset,cgeindex,cgechar
21 ****
22 start
23 finish endunit
24 write stat,1010> Loading the CGE Character Set
25 charset cgeindex,cgechar
26 erase,
27 dataon
28 area eev01
29 ext 0

part=1, block=b

block 1b, x01m0a

31 unit x01m0a
32 restart
33 base
34 next x01m1a
35 join imode
36 jump n47,x01m0a,x
37 erase

38 at 500
39 write THE OPERATION and USES of the OSCILLOSCOPE,
40 ANALAB DUAL TRACE SCOPE TYPE 1120
41 with TYPE 700 PLUG-IN

42 When you have completed this experiment
43 you should be able to :

- 44 1) Find and Adjust a Spot on the CRT Screen.
- 45 2) Measure Constant Voltages.
- 46 3) Measure Time-Varying Voltages.
- 47 4) Use the NULL dials.
- 48 5) Display Two Voltages vs Time simultaneously.
- 49 6) Display a Lissajous Figure.

----- part=1, block=c -----

block 1c, >@imia

51 unit >@imia
52 base >@imia
53 erane >@imia
54 back >@imia
55 next >@imib
56 help >@isia
57 at 1410
58 write Find the spot on the screen and position it at
59 10,00, i.e., the center of the CRT screen.

60 CAUTION: Keep the INTENSITY only as high as
61 you need to see the spot. Otherwise, damage to
62 the screen may occur.

63 at 13620
64 write -HELP- is available.
65 >@x

66 unit >@imib
67 base >@imia
68 back >@imia
69 next >@imic
70 help >@isia
71 at 14005
72 write

The spot should be a sharp point of light with no halo.

73 If it is not, adjust the INTENSITY and FOCUS
74 controls to correct the condition of your spot.
75 at 3020
76 write -HELP- is available.
77 ***

78 unit x01mic
79 restart
80 base
81 back x01m1b
82 next x01m1c1
83 lab x01s1d
84 help x01s1g
85 at 1210
86 write

Now that the spot is centered, balance the
A PRE AMP before proceeding. Press -LAB- for an
explanation of the PRE AMP Balancing Procedure.

89 When you have verified the balance of the A PRE
90 AMP, set the dials so the spot will be deflected
91 5 cm when a voltage of + 10-volts is applied
92 to the A INPUT of the SCOPE.

93 at 3020
94 write -HELP- is available.
95 ***

96 unit x01m1c1
97 pack n33,++n+fh(cd) (ae) ++++++
98 join ckd
99 jump n47,x,x01m2a,x
100 pack n33,+++++(cd) ++++++
101 join ckd1
102 jump n47,x01s1i,x01s1f

----- part=1, block=d -----

block 1d, x01m2a

104 unit x01m2a
105 back x01mic
106 next x01m2a1
107 help x01s2a
108 at 1007
109 write Great! You correctly set the dials.

110 Now, make connections and dial settings so you can
111 display the voltage from the DC Supply on the A channel
112 of the SCOPE. A positive voltage should cause an
113 upward deflection.

114 As usual, press -NEXT- when you finish.

115 "-HELP- is available.
116 ***

117 unit x01m2a1
118 jump user='author'\$and\$station#251,x01m2b,x
119 pack n33,+++++*****a++b00000000ba0+00
120 join ckd
121 jump n47,x01m2a2,x01m2a3
122 ***

123 unit x01m2a2
124 pack n33,+++++*****a++b00000000ab0+00
125 join ckc1
126 jump n47,x01s2a,x01m2a4
127 ***

128 unit x01m2a3
129 pack n33,++n+fh+ (ae) (ab) +++++++
130 join ckd
131 jump n47,x01s2a1,x
132 pack n33,+++++c++++++
133 join ckd1
134 jump n47,x01s2b,x01m2b
135 ***

136 unit x01m2a4
137 pack n33,++n+fh+ (ae) (ab) +++++++
138 join ckd
139 jump n47,x01s2a1,x
140 pack n33,+++++d++++++
141 join ckd1
142 jump n47,x01s2b,x01m2b
143 ***

144 unit x01m2b
145 back x01m2a
146 next x01m2b1
147 ab 1207
148 write Without changing anything on the SCOPE, deflect
149 the spot to Y = 5 cm.

150 HINT. To make the DC Supply function properly,
151 you must set the CURRENT dial to about 100 ma then,
152 adjust the VOLTAGE dial until the 5 cm deflection
153 is achieved.
154 ***

155 unit x01m2b1
156 pack n33,++n+fh (cd) (ae) ++++++ (def) (bodefghijklmnopqrstuvwxyz) +++++
157 join ckd
158 jump n47,x01s2c,x01m2c
159 ***

160 unit x01m2c
161 back x01m2b
162 next x01m2d
163 vat 1210

164 write

Observe the effects of the A PREAMP control.

165

How many centimeters deflection do you get
using the AC setting?

166

1635

167

arrow

168

answer

169

at

170

write

171

The AC refers to the type of coupling. AC coupling
implies that there is a capacitor in the input circuit,
to block the dc or average component.

172

173

If the spot is not at 0 you have done something
wrong...Check your balancing again, and if that
doesn't help call your instructor.

174

175

181a

----- part 1, block e -----

block 1e, x01m2d

179 unit x01m2d

180 base

181 bal . v01m2d

182 next x01m2d1

183 lab . v01m2d

184 help . v01m2d

185 at . 1007

186 write

Similarly, the spot can be deflected horizontally.

187 Balance the B PPE AMP, if you have not done so. You
may review the balancing procedure by pressing LAB-.

188 Set the dials and make the connections necessary
to deflect the spot 4 cm horizontally when a voltage
of +4 volts is applied the B INPUT of the SCOPE. The
Y DISPLAY must be set to Rows B.

189 Set the B PPE AMP to DC+.

194 ***

195 unit x01m2d1

196 pack r32,h++(cd) f8,(cd) ++++++(cd) (bcdefghijklmnopqrstuvwxyz) +***

197 join bkd

198 jump n47,x01m2d3,x01m2d2

199 ***

200 unit x01m2d2

201 pack r33,aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaagff+aa

202 join che

203 jump n47,x01m2e,x01m2e

204 ***

205 unit x01m2d3
 206 pack n33, n++ (cd) fhe ++++++ (bcd), (bcdefghijklmnopqrstuvwxyz) +***
 207 join chd1
 208 jump n47, x01s2e, x
 209 pack n33, 000000000000g00+a0000000ag0+00
 210 join cke
 211 jump n47, x01s2e, x01m2e
 212 *
 213 unit x01m2e
 214 back x01m2d
 215 next x01m2e1
 216 at 517
 217 write Without changing A VOLTS or B VOLTS dials.
 218 reflect the spot to:
 219 X=2cm Y=3cm
 220 Try to do this and then press -NEXT-, as always.
 221 You will be guided automatically if you have difficulty.

 223 unit x01m2e1
 224 jump user + 'author' \$and\$station=251, x01m2f, x
 225 pack n33, n+n (cd) ++ (cd) e ++++++ (bcd) (bcdefghijklmnopqrstuvwxyz) +***
 226 join chd1
 227 jump n47, x, x01m2e2
 228 pack n33, +++++++ (bcd) (bcdefghijklmnopqrstuvwxyz) +***
 229 join chd1
 230 jump n47, x01s2g, x01s2f
 231 ***
 232 unit x01m2e2
 233 pack n33, +++++++ (bcd) (bcdefghijklmnopqrstuvwxyz) +***
 234 join chd1
 235 sales n47, n70#00, -1
 236 pack n33, +++++++ (bcd) (bcdefghijklmnopqrstuvwxyz) +***
 237 join chd1
 238 jump n47, x01m2e3, x
 239 jump n70, x01m2f, x01s2h
 240 ***
 241 unit x01m2e3
 242 pack n33, +++++++ (bcd) (bcdefghijklmnopqrstuvwxyz) +***
 243 join chd1
 244 jump n47, x01s21, x
 245 jump n70, x01s2h, x01m2f
 246 ***
 247 unit x01m2f
 248 back x01m2e
 249 next x01m3a
 250 at 718

Do not change the dial settings on the SCOPE.

298 appears as a vertical line.
299 no
300 at
301 write
302 You should see a vertical line,
303 If you don't, press BACK to go through
304 this section again.
305 ***

305 unit ~01m3c1
306 back ~01m3b
307 next ~01m3c1
308 help ~01s3h
309 at ~10
310 write In order to make this waveform appear
311 on the SCOPE as a sine wave, it is
312 necessary to sweep the display horizontally:
313 To do this, you must apply a periodic
314 linearly-increasing voltage to the SCOPE's
315 horizontal input for a timed sweep.

316 Turn the A' PRE-AMP to OFF and apply a 0.9 Hz
317 non-adjustable RAMP wave from the FUNCTION
318 GENERATOR to the B INPUT of the SCOPE.

319 Set B VOLTS to 50 V.
320 at ~020
321 write HELP is available.

----- part=1, block=g -----

block 1g, ~01m3c1

323 unit ~01m3c1
324 pack n03,n+ndfhee+ac(rst)++(abcde)+++ (cd) a (bc) +
325 join chd
326 jump n47,~01s2j,~01m3c2
327 ***

328 unit ~01m3c2
329 pack n03,+++++++g++abefgagbfegegag
330 join chd
331 jump n47,x,~01m3d
332 pack n03,+++++++g++a++++++ag++
333 join chd
334 jump n47,~01s2j,x
335 at ~10

336 write You did not apply the non-adjustable
337 RAMP wave correctly!
338 pause
339 jump ~01m3c2
340 ***

341 unit ~01m3d

342 back >x81m3c
343 next >x81m3d1
344 at 510
345 white

As you see, this makes the spot sweep across the screen as a linear function of time.

347 Now, set the A FRE AMP to DC+ and the FUNCTION GENERATOR to 9 Hz.
349 ***

350 unit >x81m3d1
351 pack >n33,+nchfchc+ad(frst)++(abode)++++++
352 join chd
353 jump n47,x,>x81m3e
354 at 1410
355 white

Read the problem carefully!!! You were given only two dials to change.

360 unit >x81m3e
361 base
362 back >x81m3d
363 next >x81m3el
364 help >x81s3k
365 at 3007

Good! You should now have a sine wave displayed on the screen.

However, there are 2 things wrong with this display:

1) There is a visible retrace when the spot comes quickly back to the left.

2) The display is not stable.

To solve the first problem:

The SWEEP system of the SCOPE can be used to internally generate a ramp wave and blank out the return trace.

To solve the second problem:

The TRIGGER SOURCE of the SCOPE can automatically start the SWEEP at the beginning of each period.

Make the necessary adjustments to solve both these problems, and remove any unnecessary connections.

379 at 3020
380 white -HELP- is available.
381 ***

383 unit >x81m3el
384 pack n33,+n++(fg)+a+++++++(cd)a(bc)+
385 join chd
386 jump n47,>x81s3l,x

387 pack n33,++++++g++a0000000000ag00
388 join g00
389 jump n47,x01m3m,x01m4a

----- part=1, block=h -----

block 1h. x01m4a

391 unit x01m4a
392 restart
393 join imode
394 jump n47,x01m4a,x01m4a0
395 new

396 unit x01m4a0

397 base

398 next x01m4e

399 next x01m4a1

400 help x01s4s

401 at 507.7

402 write Display on the A channel of the SCOPE, a nonadjustable SINE wave having a frequency of 200 Hertz from the FUNCTION Generator.

Externally trigger the SCOPE from the FUNCTION GENERATOR.

-HELP- is available

403 ***

409 unit x01m4a1

410 pack n33,++++++a+b00a000b000+00

411 join c1cw

412 next n47,x01m4a0,x

413 jump n47,x,x01m4a2

414 new

415 unit x01m4a2

416 pack n33,+++ (cd) (de) (abcd) abaf (bcd) ++++++

417 join c1dw

418 next n47,x01m4a0,x

419 jump n47,x,x01m4b0

420 new

421 unit x01m4b0

422 next x01m4b

423 back x01m4a

424 at 1210

425 write Leave this waveform on the screen. You will need it again later on.

426 new

428 unit x01m4b

```
429 base
430 back x0im4a
431 next x0im4c
432 help x01e4b
433 zero n70
434 at 1207
```

The NULL dials, with the TIME and the A and B VOLTS dial's, can be used in measuring values on the CRT display. For this use, the NULL dials must be set at zero initially.

The value of a voltage point is measured by rotating the associated NULL dial until the voltage point being measured is returned to the zero voltage level of the display. The manner in which the value of the voltage is read will be discussed when you press -NEXT-.

Press -HELP- if you do not understand the meaning of the phrase 'zero voltage level'.

```
445
446
447
448 unit >0im4c
449 circle 144,248,256
450 circle 40,248,256
451 at 237,368
452 size 1
453 write 0.0
454
455 0.0
456
457 0.0
458 size 1
459 rotate -90
460 at 358,269
461 write 2.0
462 at 326,278
463 write 0.8
464 at 299,278
465 write 0.4
466 rotate 180
467 at 256,198
468 write 0.8
469 at 256,167
470 write 1.6
471 at 256,137
472 write 74.0
473 draw 1632;skip;1632
474 draw 192,389;134,447;skip;305,387;364,446
475 circle 112,248,268,57,122
476 draw 730;215,417;skip;734;275,419
477 circle 116,133,303,99,119
478 circle 124,268,296,83,61
479 circle 174,247,275,121,58
480 rotate 0
481 calc n70e0
482 at 243,403
```

483 write V
484 goto >01m4d
485 rotate 0
486 size 0

----- part-1, block-i -----

block ii, >01m4d1

488 unit >01m4d
489 calc n70en70+1
490 jump (n70=4),>01m4e,x,x
491 mode erase
492 at 275,424
493 writec n70,...,1,2
494 mode write
495 at 275,424
496 writec n70,...,1,2,5
497 rotate 180
498 join n70,x,x,>01m4d1,>01m4d2,>01m4d3
499 rotate 0

500 size 76
501 mode erase
502 join n70,x,x,x,>01m4d4,>01m4d5
503 mode write
504 join n70,x,x,>01m4d4,>01m4d5,>01m4d6
505 size 4
506 pause
507 goto >01m4d
508 ***

509 unit >01m4d1
510 at 222,312
511 write 4
512 ***

513 unit >01m4d2
514 mode erase
515 at 222,312
516 write 4
517 mode write
518 at 222,344
519 write 4
520 ***

521 unit >01m4d3
522 mode erase
523 at 222,344
524 write 4
525 mode write
526 at 222,375
527 write 4
528 ***

529 unit x01m4d4
530 at 2810
531 write When either the A or B VOLTS dial is set at
532 1, 10, or 100, read the NULL on the bottom scale.
533 ***

534 unit x01m4d5
535 at 2810
536 write When the A or B VOLTS dial is set at
537 2, 20, or 200, read the NULL on the middle scale.
538 ***

539 unit x01m4d6
540 at 2810
541 write When the A or B VOLTS dial is set
542 5, 50, or 500, read the NULL on the top scale.
543 ***

544 unit x01m4e
545 next x01m4f
546 size 0
547 at 1410
548 write Now that you know what scale to read on the NULL
549 dial, you can measure a voltage point by taking the
550 reading on the NULL and moving the decimal point
551 to the right by the number of zeros in the number
552 displayed in the FULL SCALE window.
553 ***

554 unit x01m4f
555 back x01m4b
556 next x01m4g
557 at 1210
558 write If the A VOLTS dial was set at 100 mV and
559 the NULL reading was .5, what would be the voltage?
560 a.) 5 mV
561 b.) 5.0 V
562 c.) 50 mV
563 d.) 5000 mV
564 arrow 2215
565 specs bumpshift
566 answer c
567 wrong b
568 at 2410
569 write The answer is in mV not V.
570 wrong f,a,d
571 at 2410
572 write There are two zero's in the A Volts
573 reading, and $10^2 \times .5 = 50$.
574 ***

575 unit x01m4g
576 next x01m5a
577 back x01m4f
578 help x01m4b
579 pack n33,++++++a+b00a00b000+00

580 join ckcc
581 jump n47,x01s4c,x
582 pack n33,+++++(cd)(de)(abdc)abaf(bcd)++++++
583 join ckcd
584 jump n47,x01s4c,x
585 at 1308
586 write Measure the peak-peak voltage of the sine wave
587 displayed on the Scope using the A VOLTS NULL DIAL.

588 What is the measured voltage volts
589 arrow 1640
590 ansv 41.10

----- part=1, block=j -----

block 1j: x01m5a

592 unit x01m5a
593 restart
594 join 1mode
595 jump n47,x01m5a,x01m5a0
596 ***
597 unit x01m5a0
598 base
599 back x01m4f
600 next x01m5a1
601 lab x01s1e
602 at 910
603 write This oscilloscope is capable of displaying two
604 waveforms at the same time, which is very useful
605 in comparison measurements.

606 Using the FUNCTION GENERATOR, apply a nonadjustable
607 SINE wave to channel A and a nonadjustable SQUARE
608 wave to channel B of the SCOPE.

609 Trigger the SCOPE from the FUNCTION GENERATOR.

610 Each time you begin a new series of measurements,
611 it is advisable to recheck the dc balance of the
612 A and B PRE AMPS, and rezero the traces.

613 Press -LAB- to review the balancing procedure.

614 ***
615 unit x01m5at
616 pack n33,+++++*****abcbfa000c000+00
617 join ckow
618 next n47,x01m5a0,x
619 jump n47,x,x01m5b
620 ***
621 unit x01m5b

```
622 back x01m5a0  
623 next x01m5b1  
624 at 510  
625 write Set the frequency at 40 Hertz, and display  
626 both traces simultaneously, with TIME FULL SCALE  
627 at 100 ms.  
628 ***
```

```
629 unit x01m5b1  
630 pack n33,+m (abcd) (cd) (de) (abod) obae (ghi) ++(abcd) ++++++  
631 join ckdw  
632 jump n47,x,x01m5c  
633 next x01m5b  
634 ***
```

```
635 unit x01m5c  
636 back x01m5b  
637 next x01m5d  
638 at 1207  
639 write For the most stable display of a low frequency  
signal the CHOP setting of the Y DISPLAY is desirable.  
640 ***
```

```
642 unit x01m5d  
643 back x01m5c  
644 next x01m6a  
645 at 1210  
646 write Experiment on your own for awhile. Change  
647 the frequency of the wave and the TIME dial.
```

```
648 Note which setting of the Y DISPLAY (ALT or CHOP)  
649 gives the best display.  
650 ***
```

```
651 unit x01m6a  
652 back x01m5d  
653 next x01m7a  
654 at 1314  
655 write Set the Y DISPLAY FUNCTION to A vs B.
```

```
656 pause  
657 pack n33,++++++e+++++++++  
658 join ckd  
659 jump n47,x01s6a,x  
660 at 1610  
661 write The pattern you see on the SCOPE is called  
662 a LISSAJOUS figure. Change the wave INPUTS to  
663 the SCOPE (SQUARE, SINE, TRIANGLE; RAMP) to get  
664 different patterns.
```

part=1, block=k

block lk, x01m7a

```
666 unit x01m7a
```

657 restart
 658 join mode
 659 jump 647, +81m7a, x81m7aa
 660
 661 unit 881m7aa
 662 base
 663 back 81m7aa
 664 next 81m7aa
 665 at 647
 666 begin Set the FUNCTION GENERATOR at 4000 Hz and connect
 one minadjustable SQUARE wave to channel B.
 667
 668 Connect the AUDIO OSCILLATOR to the A channel
 with a frequency of 3000 Hz, and adjust the AMPLITUDE
 to a comfortable level.
 669
 670 Invert the SCOPE from the FUNCTION GENERATOR.
 671
 672 Adjust the display until both voltages appear.
 673 Turn the A/B SEPARATION knob, to the left of the CRT
 screen, adjusting the separation of the zero base lines
 of the A and B traces.
 674
 675 If you have superposed the traces by reducing the
 separation of the zero base lines to zero, or, you
 have separated them by raising the B zero base lines
 by $+2$ and lowering the B zero base lines to
 -2 , turn both the FINE ADJ's to OFF while
 making this, your adjustments will be more accurate.
 676 ***
 677
 678 unit 881m7a
 679 next 81m7aa
 680
 681 begin 81m7a, ++(abcd)(efg)(def)(abcd)bas(ghi)++(abcd)+++(fgh)
 682 from 81m7a
 683 jump 647, +81m7b
 684
 685 unit 881m7b
 686 back 81m7a, 81m7b
 687 next 81m7b
 688 at 81m7b
 689 end if both traces established
 690
 691 if true 81m7a
 692 answer 81m7a
 693 at 81m7a
 694 unit 81m7a
 695
 696 which is the stable trace? (square or sine)

715 no
716 at 710
717 write If they are, then you aren't!!!
718 arrow 1037
719 specs bumpshift
720 answer (square) <wave>
721 ***

722 unit x01m7c
723 back x01m7b
724 next x01m7d
725 at 507
726 write Set the TRIGGER SOURCE so that both traces are stable.
727 ***

728 unit x01m7d
729 back x01m7c
730 pack n33,+++++(fg) +++++++
731 join ckd
732 jump n47,x01s7a,x
733 at 1010
734 write Correct! On the INT trigger settings, the
traces trigger independently.
735 next n47,x01m7c,x01end

----- part=1, block=1 -----

block 11. x01s1a

737 unit x01s1a
738 next x01s1b
739 back x01s1c
740 at 1007
741 write Adjust the INTENSITY and FOCUS controls so that
the spot is a sharp point of light with no halo.

The X POSITION and Y POSITION controls are used
to move the spot around the screen.

If no spot appears on the screen, even at full
INTENSITY, use the BEAM FINDER control to locate it.

Press -NEXT- for information on use of BEAM FINDER.

Set the SCALE illumination control at 8.0.

When the spot is properly adjusted, press -BACK-.

750 ***

751 unit x01s1b
752 back x01s1a
753 next x01s1c
754 at 507
755 write USE OF THE BEAM FINDER:

756
757 1) Turn and hold the black BEAM FINDER knob fully CW.
758
759 2) The spot should appear on the screen. Center it,
 using the Red X and Y POSITION knobs.
760
761 3) Release the BEAM FINDER when the spot is within
762 a few cm of the center, and the spot should remain,
at 3005
763 If you still can't locate the spot call your instructor.
764 end
765 ***

766 unit x01sic
767 press next
768 end
769 ***

770	unit	>01s1d
771	back	>01mic
772	next	>01sie
773	at	1007
774		

Before using the SCOPE for any investigation, the A and B preamplifiers must be balanced. This is essentially an adjustment of the linearity of their dc amplifiers.

778 Balance the A, PRE AMP using the procedure you
779 will see when you press <NEXT>.
780 ***

781 unit visible
782 at 510
783 write BALANCING PROCEDURE

For the preamplifier you want to balance:

- 785 1) Set PRE AMP to OFF.

786 2) Set VOLTS FULL SCALE to 1mv., and center the trace.

787 3) Set PRE AMP to BAL SET and use the BAL screw
788 to center the spot. Use the beam finder if
789 needed. (BAL Screw has both fine and coarse
790 adjustment. Adjust slightly past center and
791 then back for finer control)

792 4) Check to see that the preamplifier is balanced by
793 switching the PRE AMP between OFF and BAL SET.
794 If the spot moves, repeat the balancing procedure.

795 5) Return VOLTS FULL SCALE to desired setting.
796 Call your instructor, if you are unable to
797 properly balance the PRE AMPS !

block 1m, x01sif1

800 unit x01sif
801 back x01sig
802 next x01sig
803 at 1210

804 write Something is wrong with your set up.
805 You will be given information on the dials
806 before you are allowed to try again. Press
807 -NEXT- for this information.

808 ***
809 unit x01sig
810 next x01sh
811 at 510

812 write The number in the window of the
813 A VOLTS FULL SCALE dial represents the voltage
814 required for a full scale deflection of 10 cm.

815 With A VOLTS FULL SCALE set at 20 volts, the
816 sensitivity (volts/cm.) would be

817 arrow 1043
818 answer <volts,volt,cm>(2)

819 at 1207

820 write What is the minimum number of cm needed to deflect
821 the spot to the edge of full scale from (0,0) ?

822 arrow 1530

823 answer <cm>(5)

824 at 2007

825 write Setting A VOLTS FULL SCALE to 10 volts provides
826 a deflection of 10 cm for a 10 volt signal. However,
827 since the spot is now at (0,0), a setting of 20 V
828 will allow the spot to remain on the screen when a
829 10 volt signal is applied.

830 wrong 10

831 at 1710

832 write If the spot were centered at the bottom of
833 the screen, full scale deflection would be 10.
834 Try again remembering the spot is at (0,0)

835 ***

836 unit x01sh
837 at 1110

838 write When applying a constant voltage to one of
839 the channels, the Y DISPLAY must be set to that
840 channel, or to the A vs B position.

841 The TRIGGER SOURCE and the SWEEP MODE
842 should be set in the OFF position for constant
843 signals.

844 end

845 ***

846 unit >x01s11
847 back >x01m1c
848 next >x01m1c
849 at 1310

850 write You cannot deflect the spot with the A PRE AMP
in the OFF position.

851

852

853

854 To what position should the A PRE AMP be set
855 to deflect the spot?

856 arrow 1340

857 specs jumpshift

858 answer (dc)

859 trying fact

860 at 1310

861 write No! You are applying a dc or constant voltage.

----- part=1, block=n -----

block in, x01s2a

863 unit >x01s2a

864 back >x01m2a

865 next >x01m2a

866 at 1307

867 write Connect the "+" terminal of the DC SUPPLY to the
868 A INPUT of the SCOPE and the "-" terminal to ground.

869 The DC SUPPLY generator circuit is not internally
870 grounded, that is, it is floating. However, there
871 is a common-ground terminal to the right of the +
872 and - terminals to which an external ground
873 connection can be made.

874 ***

875 unit >x01s2a1

876 next >x01m2a

877 back >x01m2a

878 at 1306

879 write You have unnecessarily changed some of the dials.
880 The only dials you may have needed to change were
881 the A PRE AMP and the X DISPLAY. Return all other
882 dials to where they were before.

883 ***

884 unit >x01s2b

885 back >x01m2a

886 next >x01m2a

887 at 1410

888 write You did not set the A PRE AMP to allow
889 a positive voltage to cause upward deflection.

890 ***

891 unit x01s2c
892 base
893 back x01m2b
894 next x01m2b1
895 lab x01s1e
896 at 1310
897 write You did not deflect the spot 5 cm properly.
898 On the DC SUPPLY, verify that you have set the CURRENT
899 to at least 100 mA and the VOLTAGE to provide a 5
900 cm deflection. Press -LAB- if you want to
901 rebalance a PRE AMP.
902 ***

903 unit x01s2d
904 at 1210
905 write The B channel deflects the spot in
906 a manner similar to that of the A channel.

907 The A channel deflects vertically and the B channel
908 deflects horizontally with A vs B.

909 After you return to the task statement,
910 you can repeat the A channel again by pressing -BACK-.
911 end

----- part=2, block=a -----

block 2a, x01s2e1

913 unit x01s2e
914 back x01m2a
915 next x01m2d
916 at 1210
917 write You seem to have trouble deflecting the spot
918 horizontally. You should have turned the A PRE AMP to
919 OFF or should have disconnected the connection to
920 the A INPUT. Press -NEXT- to try again.

921 Press -BACK- to repeat the vertical deflection task.
922 ***

923 unit x01s2f
924 back x01m2e
925 next x01m2e
926 at 1210
927 write You incorrectly set the dials.
928 pause
929 erase
930 at 810
931 write The vertical deflection is controlled
932 by the channel with Y DISPLAY at A vs B.
933 arrow 917
934 specs bumpshift

935 answer a
936 at 1210
937 write The horizontal deflection is controlled
938 by the channel with the Y DISPLAY at A vs B.
939 arrow 1317
940 specs bumpshift
941 answer b
942 at 1610
943 write Then to control both the A and the B
944 channels, the Y Display should be set to
945 arrow 1750
946 specs bumpshift
947 answer (a) (vs, versus, vs) (b)
948 at 2010
949 write Both the A and the B PREAMPs should
950 be set in the position to deflect
951 the spot.
952 arrow 2124
953 specs bumpshift
954 answer dc
955 at 2410
956 write Set the A and B VOLTS FULL SCALE dials to 20 V.
957 ***

958 unit >01s2g
959 back >01m2e
960 next >01m2e
961 at 1310
962 write You incorrectly set the DC SUPPLY. Make
963 sure that a 3 cm deflection is obtained.
964 ***

965 unit >01s2h
966 back >01m2e
967 next >01m2e
968 at 1210
969 write You did not set the A and B PRE AMPs so
970 a positive voltage would cause upward deflection.
971 ***

972 unit >01s2i
973 back >01m2e
974 next >01m2e
975 at 1210
976 write You incorrectly connected the DC SUPPLY to
977 the SCOPE!

----- part=2, block=b -----

block 2b, >01s3a

979 unit >01s3a
980 basva
981 back >01m3a

982 next x01m3a
983 lab x01s3b
984 data x01s3c
985 at 1210
986 write - Press the desired key for the information
you want;
987

-LAB- Voltage peak to peak or V_{p-p}.
-DATA- Connections.
-NEXT- To return to the task.

991 ***

992 unit x01s3b
993 back x01m3a
994 next x01m3a
995 origin 72.352
996 axes 0., -101, 300, 100
997 scalex 2π
998 scaley 10
999 marks π, π/4
1000 labelv 10, 2.5
1001 alfa ..
1002 funct 10sin(γ77), γ77
1003 at 2510
1004 write What is the peak to peak voltage of this wave?
1005 arrow 2556
1006 ansv 20.2
1007 no ..
1008 at 2710
1009 write The peak to peak voltage is the voltage between
V_{max} and V_{min}.
1010 hbar 372, 10, -
1011 graph 372, 10, V_{max}
1012 hbar 372, -10, -
1013 graph 372, -10, V_{min},
1014 vector 9π/4, 0, 9π/4, 9.6
1015 vector 9π/4, 0, 9π/4, -9.6
1016 vector 1054
1017 at ..
1018 write V_{p-p}
1019 write
1020 end ..
1021 ***

1022 unit x01s3c
1023 next x01m3a
1024 at 1210
1025 write Shown below are the three terminals
of the AUDIO OSCILLATOR. To apply a sine
wave to the A INPUT of the SCOPE,
the A INPUT must be connected to what
terminal of the AUDIO OSCILLATOR. (A, B, or C)
1026 circle 8, 160, 192
1027 circle 8, 192, 192
1028 circle 8, 224, 192
1029 draw 2026; 200, 178; 194, 172; 157, 172; 152, 177; 152, 191
1030 skip: 167, 191; 167, 183; 184, 183; 184, 191
1031 at 157, 184

1036 write A B C
1037 arrow 1740
1038 specs bumpshift
1039 answer C
1040 at 2410
1041 write This is the only connection you need since
1042 the SCOPE and the AUDIO OSCILLATOR are internally
1043 grounded.
1044 wrong (a,b)
1045 at 2410
1046 write Not Terminal B is connected to ground.
1047 Notice the ground strap between A and B.
1048 no
1049 at 2410
1050 write NOT! Type the letters A, B, or C.
1051 end
1052 ***

1053 unit >01s3d
1054 next >01s3c
1055 at 1010
1056 write You incorrectly connected the AUDIO OSCILLATOR
1057 to the SCOPE. Press -NEXT- for help.
1058 ***

1059 unit >01s3e
1060 next >01m3a
1061 at 1010
1062 write You were not to change the dials on the SCOPE!
1063 Reset them in these positions:

A VOLTS FULL SCALE	20 V
SWEEP MODE	OFF
TRIGGER SOURCE	OFF
A PRE AMP	+DE
DISPLAY	A vs B

1064
1065
1066
1067
1068
1069 ***

1070 unit >01s3f
1071 next >01m3a
1072 at 1010
1073 write The output frequency of the AUDIO OSCILLATOR is
1074 incorrectly set. Remember the output frequency
1075 is the product of the RANGE dial and the frequency
1076 dial.

----- part=2, block=c -----

block 2c. >01s3g

1077 unit >01s3g
1078 base >01m3a
1079 next >01m3a

1081 help ~8153b
1082 at 1310
1083 write The AMPLITUDE of the AUDIO OSCILLATOR is
1084 incorrectly set.

1085 Press -NEXT- to try again.
1086 Press -HELP- if uncertain about V_{p-p}.
1087 ***

• 1088 unit ~8153h
1089 define switch=1
1090 ; trmn1=2
1091 ground=3
1092 char trmn1
1093 ~0000016,0000033,0000021,0000033,0000016,0000000,0000000,0000000
1094 char switch
1095 ~0000000,0000340,0000760,0001777,0001777,0000760,0000340,0000000
1096 char ground
1097 ~0000000,0100000,0120000,0124000,0124000,0120000,0100000,0000000
1098 draw 1606;1635;2135;2106;1606
1099 circle 8,160,217
1100 circle 25,160,217
1101 circle 4,184,199
1102 circle 10,224,227
1103 circle 6,224,227
1104 at 256,245
1105 plot trmn1
1106 at 256,235
1107 plot trmn1
1108 at 256,225
1109 plot trmn1
1110 at 256,215
1111 plot trmn1
1112 at 256,205
1113 plot trmn1
1114 at 256,195
1115 plot trmn1
1116 at 240,185
1117 plot trmn1
1118 at 222,185
1119 plot trmn1
1120 circle 5,201,185
1121 circle 8,115,230
1122 circle 8,83,230
1123 at 51,237
1124 plot trmn1
1125 at 51,227
1126 plot trmn1
1127 at 51,217
1128 plot trmn1
1129 at 68,186
1130 plot switch
1131 at 210
1132 write The nonadjustable outputs have fixed voltages.
There is no way to alter this.
1133 size 5
1134 at 279,208

```
1136 write }
1137 size '
1138 at 1839
1139 write Nonadjustable
1140 Outputs
1141 pause :
1142 at 610
1143 write The adjustable OUTPUT is controlled by the
1144 ATTENUATOR, the OUTPUT selector, and the DC LEVEL.
1145 The ATTENUATOR and DC LEVEL controls are interdependent.
1146 draw 224,125;224,181;skip;228,179;224,183;220,179
1147 at 184,108
1148 write Adjustable
1149 OUTPUT
1150 draw 140,121;198,179;skip;198,174;198,179;193,179
1151 at 48,117
1152 write DC LEVEL
1153 draw 222,225;265,268;skip;222,230;222,225;227,225
1154 at 1534
1155 write ATTENUATOR
1156 draw 160,271;215,236;skip;211,235;216,235;216,240
1157 at 1515
1158 write OUTPUT
1159 end
```

----- part=2, block=d -----

block 2d, x01s3i

```
1161 unit x01s3i
1162 next' ~01m3c
1163 at 1310
1164 write You incorrectly set the dials. Read the
1165 problem carefully. You are given which dials
1166 you needed to change.
1167 ***
1168 unit x01s3j
1169 next' ~01m3c,
1170 at 1310
1171 write It is necessary to again drive the A channel from
1172 the AUDIO OSCILLATOR.
1173 ***
1174 unit x01s3k
1175 back ~01m3e
1176 next' ~01m3e
1177 at 705
1178 write The Y DISPLAY FUNCTION should be set to the
1179 position to display the sine wave on the A INPUT
1180 arrow 749
1181 spec bumpshift
1182 answer a
1183 at 1205
```

1184 write To internally trigger the SCOPE, the TRIGGER
1185 SOURCE should be set at
1186 no
1187 at 1005
1188 write The Y DISPLAY FUNCTION should be set to the A
1189 position to display the sine wave on the A channel.
1190 arrow
1191 specs
1192 answer bumpshift
1193 at <ac,dc>(int,internal)
1194 write 1810
1195 The SWEEP MODE should be set to the DRIVEN -
VARIABLE LENGTH position.

1196 Set the TIME at 50 ms (frequency), so that one
1197 period (T) of the sine wave appears on the screen.
1198 no

1199 at 1510
1200 write The TRIGGER SOURCE should be set to the INT
1201 position when you internally trigger the SCOPE
1202 end
1203 ***

1204 unit >x01s3l
1205 next >x01s3k
1206 at 1210
1207 write You have incorrectly set the dials.

1208 Instructions on how to correct these errors
1209 will be given when you press NEXT.
1210 ***

1211 unit >x01s3m
1212 next >x01s3l
1213 at 1210
1214 write You don't need that wire connected to the B INPUT.

----- part=2, block=-----

block 2e. >x01s4a!

1216 unit >x01s4a
1217 next >x01s3h
1218 at 5MS
1219 write To what position must the TRIGGER SOURCE be set
1220 to permit the SCOPE to be externally triggered?
1221 arrow 653
1222 specs bumpshift
1223 answer <ac,dc>(ext,external)
1224 at 1410
1225 write The only connection needed to externally
1226 trigger the SCOPE from the FUNCTION GENERATOR
1227 is a connection from the _____ terminal of
1228 the SCOPE to the _____ terminal of the
1229 FUNCTION GENERATOR.

1230 no
1231 at 1110
1232 write It should be set in an EXT position.
1233 arrow 1634
1234 specs bumpshift
1235 answer <the,terminal>(trig,trigger)(in,input)
1236 no
1237 at 2410
1238 write The terminal on the SCOPE is the TRIGGER INPUT.
1239 arrow 1726
1240 specs bumpshift
1241 answer <the,terminal>(trig,trigger)(out,output)
1242 jump x01s4b
1243 no
1244 at 2410
1245 write The terminal on the FUNCTION GENERATOR is
1246 the TRIG OUT.

part=2, block=f

block 2f, x01s4b1

1248 unit x01s4b
1249 define spot=1
1250 char spot
1251 o000014, o000036, o000071, o000077, o000033, o000014, o000000, o000000
1252 join x01s4b1
1253 at 245,320
1254 plot spot
1255 at 2510
1256 write To measure the voltage of this deflection
move the NULL dial until the voltage point is at the
zero base line.

Press -NEXT- to see this done.

1259 pause
1260 mode erase
1261 at 245,320
1262 plot spot
1263 at 2510
1264 write To measure the voltage of this deflection
move the NULL dial until the voltage point is at the
zero base line.

Press -NEXT- to see this done.

1265 mode write
1266 at 245,253
1267 plot spot

1268 pause

1269 mode erase

1270 at x01s4b1

1271 plot fsin(v77),v77+2π,2π,1π

1272 pause

1273 mode

1274 at 2510

1275 plot If you wanted to measure the zero to

1278 peak voltage (V_{g-p}), move the trace to the
1279 zero level by adjusting the NULL. Press
1280 -NEXT- to see this done.

1281 pause
1282 mode
1283 funct
1284 at
1285 write
1286 5sin(v77),v77 \leftarrow -2 π ,2 π ,.1 π
2510

If you wanted to measure the zero to
peak voltage (V_{g-p}), move the trace to the
zero level by adjusting the NULL. Press
-NEXT- to see this done.

1289 mode
1290 funct
1291 end
1292 ***

1293 unit v01s4b*

1294 origin 1632

1295 axes -120,-120,120,120

1296 scalex .2 π

1297 scaley 10

1298 markx -.4 π ,.4 π ,2

1299 marky 2,2,2

1300 markx .4 π ,.08 π

1301 ***

1302 unit v01s4c

1303 next v01m4a

1304 back v01m4a

1305 at 1310

1306 write You did not follow my instructions to leave
1307 the waveform displayed on the screen. Press
1308 -NEXT- to display the waveform again.

1309 ***

1310 unit v01s6a

1311 next v01mfa

1312 at 1610

1313 write Set the Y DISPLAY to A vs B.

1314 ***

1315 unit v01s7a

1316 back v01m7c

1317 next v01m7c

1318 at 1310

1319 write You did not set the TRIGGER SOURCE
1320 in the correct position!

1321 end

----- part=2, block=g -----

block 2g, x01end!

1323 unit x01end

```

1324 back x01m7a
1325 join imode
1326 jump n47, x01end, x
1327 course n2
1328 calc n2='ee244',
1329 nc(n21+1) ≠ (nc(n21+1) $mask$07777777770000000000) +046030000000,
1330 nc(n21+1) ≠ nc(n21+1)
1331 output // student has completed experiment //
1332 join endunit
1333 join jmpmes
1334 jumpoutf ceeindex, quest1

```

```

1335 entry leave
1336 end lesson
1337 ***A

```

```

1338 unit endunit
1339 course n2
1340 jump n2='ee244', leave; x
1341 calc n: (n21+7) ≠ nc(n21+7) + ahelp
1342 nc(n21+6) ≠ vc(n21+6) + atime/60000
1343 ***Incl. cee.s.r. & terms sample, index, imode, comment, slides.
1344 use acc000, ok1
1345 use ch2
1346 use ch3
1347 use ch4
1348 use ch5,
1349 use ch6

```

ok1 not found 128 202 210 330 237 388 271

ok2 not found 580 411 617 696

ok3 not found 125 243

ok4 not found 98 138 138 226 157 270 197

ok5 not found 325 352 385 583 731 658

ok6 not found 417 631 702

ok7 not found 101 133 141 234 207 279 229

ok8 not found 282 285 333

endunit x01end 1338 23 1332

imode not found 35 393 594 668 1325

jmpmes not found 1333

leave x01end 1340

x01end x01end 1323 735 1326

x01m0 x01m0 31 36 54

x01m1 x01m1 51 64 68

x01m2 x01m2 66 55 81

x01m3 x01m3 78 69 105 771 847 848

x01m4 x01m4 96 82

x01m5 x01m5 104 99 145 864 977 865 985 876

x01m6 x01m6 886 914

x01m7 x01m7 17 106

x01m8 x01m8 28 121

x01m9 x01m9 128 121

x01m10 x01m10 136 126

x01m11 x01m11 144 118 134 142 161 893

x01m12 x01m12 156 146 894

x01m13 x01m13 166 158 181

x01m14 x01m14 179 162 214 915

x01m2d1	x01m2d	195	182				
x01m2d2	x01m2d	200	198				
x01m2d3	x01m2d	205	198				
x01m2e	x01m2d	213	203	211	248	959	924
			966	967	973	974	925
x01m2e1	x01m2d	223	215				
x01m2e2	x01m2d	232	227				
x01m2e3	x01m2d	241	238				
x01m2f	x01m2d	247	224	239	245	259	
x01m3a	x01m3a	256	249	289	981	994	982
			1060	1071	1080	1023	993
x01m3a1	x01m3a	269	260				
x01m3a2	x01m3a	274	272				
x01m3b	x01m3a	288	277	306			
x01m3c	x01m3a	305	290	339	342	1162	1169
x01m3c1	x01m3c1	323	307				
x01m3c2	x01m3c1	328	326				
x01m3d	x01m3c1	341	37	358	362		
x01m3d1	x01m3c1	358	343				
x01m3e	x01m3c1	360	353	398	1175	1176	
x01m3e1	x01m3c1	367	363	1212			
x01m4a	x01m4a	391	389	394	423	438	1304
x01m4a0	x01m4a	396	394	412	418		1303
x01m4a1	x01m4a	408	399				
x01m4a2	x01m4a	415	413				
x01m4b	x01m4a	426	422	555	578		
x01m4b0	x01m4a	434	419				
x01m4c	x01m4a	448	431				
x01m4d	x01m4d	466	464	507			
x01m4d1	x01m4d	509	498				
x01m4d2	x01m4d	513	498				
x01m4d3	x01m4d	571	498				
x01m4d4	x01m4d	574	507	504			
x01m4d5	x01m4d	534	502	502	504		
x01m4d6	x01m4d	539	504				
x01m4e	x01m4d	544	498				
x01m4f	x01m4d	554	545	577	599		
x01m4g	x01m4d	575	556				
x01m5a	x01m5a	592	576	595			
x01m5a0	x01m5a	497	595	618	622		
x01m5a1	x01m5a	615	608				
x01m5b	x01m5a	621	619	639	636		
x01m5b1	x01m5a	629	623				
x01m5c	x01m5a	675	637	643			
x01m5d	x01m5a	642	637	652			
x01m6a	x01m5a	651	644	673	1311		
x01m7a	x01m7a	666	653	669	706	1324	
x01m7a0	x01m7a	671	669	694	700		
x01m7a1	x01m7a	693	674				
x01m7a2	x01m7a	699	697				
x01m7b	x01m7a	705	703	723			
x01m7c	x01m2a	722	707	729	735	1316	1317
x01m7d	x01m7a	728	724				
x01s1a	x01s1a	737	56	70	752		
x01s1b	x01s1a	751	738				
x01s1c	x01s1a	766	739	753			
x01s1d	x01s1a	780	83				

x01s1e	x01s1a	781	183	601	772	895
x01s1f	x01s1f	800	102			
x01s1g	x01s1f	809	84	801	802	
x01s1h	x01s1f	836	810			
x01s1i	x01s1f	846	102			
x01s2a	x01s2a	863	107	126		
x01s2a1	x01s2a	875	131	139		
x01s2b	x01s2a	884	134	142		
x01s2c	x01s2a	891	158			
x01s2d	x01s2a	903	184			
x01s2e	x01s2e	943	203	208	211	
x01s2f	x01s2e	923	238			
x01s2g	x01s2e	958	230			
x01s2h	x01s2e	965	239	245		
x01s2i	x01s2e	971	244			
x01s3a	x01s3a	979	261			
x01s3b	x01s3a	987	983	1081		
x01s3c	x01s3a	1012	984	1054		
x01s3d	x01s3a	1053	272			
x01s3e	x01s3a	1059	280			
x01s3f	x01s3a	1070	283			
x01s3g	x01s3e	1078	286			
x01s3h	x01s3e	1086	308	1217	1242	
x01s3i	x01s3i	1161	326			
x01s3j	x01s3i	1168	334			
x01s3k	x01s3i	1174	364	1205		
x01s3l	x01s3i	1204	386			
x01s3m	x01s3i	1211	389			
x01s4a	x01s4a	1216	400			
x01s4b	x01s4b	1248	432			
x01s4c1	x01s4b	1249	1251	1274		
x01s4c2	x01s4b	1302	581	584		
x01s4d	x01s4b	1310	659			
x01s4e	x01s4b	1315	732			
ahelp		1341				
atime		1342				
erlund		1391	1896			
ne		1394	1329	1338	1338	1341
next		787				
n2		1327	1328	1339	1340	
n21		1329	1329	1339	1341	1341
n33		97	138	119	124	129
		186	201	206	209	225
		278	275	278	281	284
		384	387	418	416	579
		695	701	730		630
		86	99	103	121	126
		158	198	203	208	217
		244	273	277	280	283
		386	389	394	412	413
		595	618	619	632	659
		735	1026			703
		235	239	245	433	481
		496	468	502	504	
sin		1067	1175	1283	1308	
spot		1049	1150	1264	1363	1271
station		116	114			

switch	1089	1094	1130						
trmml	1090	1092	1105	1107	1109	1111	1117	1113	
	1119	1124	1126	1128					
user	118	224							
vc	1342	1342							
v ₂	1393	1393	1275	1275	1283	1283	1240	1298	
V _{ma}	1012								
V _{mz}	1014								
π	997	999	999	1275	1275	1283	1275	1283	1283
	1298	1298	1298	1296	1298	1298	1298	1298	1300

lesson information

lesson name = eex01

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by Neal of course eecge

at site 7, station 12

author name = J P Neal

department = EE

telephone number = 338-4351

discipline = elec. eng. lab

grade level = Freshman

description of lesson = The Operation and Uses of the Oscilloscope, Analab 1120.

----- part=1, block=a -----

block 1a, eex02id

2 stop
3 **** For Neal, CGERL, Room 248 EEB.

One line description of this lesson --

5 The Operation and Uses of the Audio Oscillator, HP 200AB.

6 Divisions of this Lesson: Block Unit

7	Id for this file	eex02id
8	Experiment eex02;	
9	Objectives	
10	Frequency adjustments	x02m0a x02m1a
11	Amplitude adjustment	x02m0a x02m2a
12	Compare w/ function generator	x02m2a2 x02m3a
13	Floating mode	x02m4a x02m4a
14	Superposition of waves	x02m5a x02m5a
15	Final test	x02m5j x02m6a

16 final edit 31 aug 74 neal

```

17 *list info
18 *list symbols
19 *list variab,charset,cgeindex,cgechar
20
21 start
22 finish endunit
23 init int(1010). Loading the CGE Character Set
24 char set cgeindex,cgechar
25 parse
26 option
27 proc rrr02
28 next

```

----- part=1, block=b -----

block 1b, x02m1a

```

30 unit x02m1a
31 restart
32 join imode
33 jump n47, x02m0a,x
34 base
35 next, x02m1a,
36 zero n50
37 zero n51

```

38 at 784
39 write THE OPERATION AND USES OF THE AUDIO OSCILLATOR, HP 200AB
40 at 1005
41 write The purpose of this experiment is to experimentally
42 study the operation of the Audio/Oscillator as a
43 sine-wave voltage generator, and use it in various modes.

44 The specific tasks of this experiment are to examine:

- 45 1) Frequency adjustments.
46 2) Amplitude adjustment and measurement.
47 3) Comparisons with the Function Generator.
48 4) The floating mode of the Audio Oscillator.
49 5) Superposition of waveforms.
50 ***

51 unit x02m1a
52 restart
53 base
54 next x02m1b
55 back x02m0a
56 at 802

57 write The Audio Oscillator produces a sine-wave voltage
58 over a range of frequencies which nearly coincides
59 with the range of audible acoustical frequencies.

60 The parameters of the generated sine-wave voltage
61 are its frequency and its amplitude. These parameters
62 can be varied by adjustments of the dials on the front
63 panel of the Audio Oscillator.

64 The output frequency in Hertz is designed to be
65 within 2 percent of the product of the settings of the
66 large frequency dial and the RANGE dial.

67 The output amplitude is adjusted by the AMPLITUDE
68 dial. This dial is not calibrated in volts.

69 ***

70 unit x02m1b
71 back x02m1a
72 next x02m0c
73 at 803
74 write Adjust the Audio Oscillator to generate a
75 frequency of approximately 5000 Hertz.
76 ***

77 unit x02m1c
78 pack n23, ++++++++(c(kl) df)+
79 join ckd
80 jump n47, x02s01a, x02m2a
81 ***

82 unit x02m1a
83 restart

84	base	
85	back	x02m1b
86	next	x02m2a1
87	help	x02s02a
88	at	708

Now that you have set the Audio Oscillator frequency properly; turn up the AMPLITUDE dial all the way and display one period of the Audio Oscillator output waveform on the A channel of the Scope so you can most accurately measure the peak-to-peak value.

Set the Sweep Mode to the Driven Variable Length Position. This is the most stable and recommended mode of operation for most signals.

Internally Trigger the scope for this setup.

98 at 2920
99 write -HELP- is available

part=1, block=0

block 1c. x02m2a2

106	unit	>v02m2a2
107	pack	n33, +ep+d(fg) (abcc) a++++++v(cd) (f1) +
108	join	ckd
109	calco	n47, n60en60+1, n60+0
110	jump	t60, x, x, >v02s04a, >v02s05a, >v02s05b
111	jump	n47, >v02s04a; >v02m2b
112	***	

113 unit / >02m3b
114 back >02m2a
115 next >02m3c
116 at 1007
117 write Measure V_{p-p} of the sine wave.

118 Hint: Peak-to-peak expansion is easiest to observe
119 when the SWEEP is turned OFF.

120 What peak-to-peak voltage did you read?

121 V_{P-P}
 122 arrow 1720
 123 ansy 85,5
 124 no
 125 at 2110
 126 write Your vol

Your voltage measurement is too inaccurate.

127 Check your measurements!

128 ***

129 unit >02m2c
130 back >02m2b
131 next >02m3a
132 at 607
133 write Good.

134 Without moving the AMPLITUDE control on the
135 Audio Oscillator, observe the amplitude of the
136 output sine wave voltage on the Scope while you
137 vary the frequency of the Audio Oscillator over
138 its entire operating range.

139 pause

140 at 1407

141 write Does the amplitude of the output vary with frequency?

142 arrow 1626

143 answer (y, yes, Y, Yes)

144 at 1707

145 write Right! The amplitude does vary somewhat.

146 wrong (n, no, No)

147 at 1707

148 write Look at it more carefully, while you vary the
149 frequency from the lowest to the highest settings.

150 ***

151 unit >02m3a

152 restart

153 base

154 back >02m2b

155 next >02m3b

156 at 807

157 write The Function Generator is also capable of producing
158 a sinusoidal waveform of adjustable frequency and
159 amplitude.

160 We will now use the Scope to compare the adjustable
161 SINE output of the Function Generator with the output
162 of the Audio Oscillator.

163 ***

164 unit >02m3b

165 back >02m3a

166 next >02m3c

167 at 1507

168 write Connect the adjustable SINE output of the Function
169 Generator to the B channel of the Scope.

170 The Function Generator is grounded by the links
171 between the lower right terminals on its front panel,
172 so only one connection from the Function Generator
173 is necessary.

174 ***

175 unit >02m3c

176 pack n33, +++++++bc+++++c+++b+++

177 join ckc
178 jump n47,x02s06a,x02m3d
179 ***

180 unit x02m3d
181 restart
182 back x02m3b
183 next x02m3e
184 at 807
185 write Set the Function Generator to produce a sine
186 wave with a frequency of 5000 Hz. and with a
187 maximum amplitude.

188 (If you would like to review the operation
189 of the Function Generator, press -LAB-.)

190 Now, set the Scope to display the A and B
191 channels alternately, with both the A and B VOLTS
192 at 100 volts and with internal triggering.
193 lab x02s07a

----- part=1, block=d -----

block 1d, x02m3e:

195 unit x02m3e
196 pack n38,p+p (bc) d(fg) (bc) db+g (ijk) bv++++++
197 join ckd
198 jump n47,x02s08a,x02m3f
199 ***

200 unit x02m3f
201 back x02m3d
202 next x02m3g
203 at 807

204 write Use the Scope to compare the output waveshapes
205 of the Function Generator and the Audio Oscillator.

206 As you experiment with various controls, make any
207 observations necessary to answer the following questions.

208 do x02s09a
209 at 1407

210 write Which instrument has the greater maximum output
211 amplitude?

212 arrow, 1536

213 answer a

214 at 1607

215 write RIGHT! The Audio Oscillator is capable of
216 producing the largest amplitude sine wave.

217 ***

218 unit x02m3g
219 back x02m3f
220 next x02m3h

221 at 807
222 write Which instrument has the higher maximum frequency?
223 at 1307
224 write Which instrument has the lower minimum frequency?
225 do x02s09a

226 arrow 938

227 bump

228 answer a

229 wrong b

230 at 1007

231 write Look at both the frequency dial and the
232 MULTIPLIER(range) dial.

233 arrow 1408

234 answer b

235 wrong a

236 at 1507

237 write Look at both the frequency dial and
238 the MULTIPLIER(range) control

239 ***

240 unit x02m3h

241 back x02m3g

242 next x02m3i

243 at 707

244 write With both sine waves at about the same frequency
245 you may be able to notice that one of the generators
246 produces a better quality sine wave.

247 Which generator is it?

248 arrow 1135

249 specs hookup,bumpshift

250 match n51,a,b

251 at 1140

252 write n51,no,ok,no

253 endarrow

254 at 1308

255 write The Audio Oscillator produces a pure sine wave
256 in its internal oscillator circuit.

257 The Function Generator produces its sine wave
258 by means of waveshaping circuits.

259 at 1309

260 write Thus the Function Generator 'sine wave' is not as
261 pure a sine wave as that of the Audio Oscillator.
262 It has noticeable imperfections.

263 ***

264 unit x02m3i

265 back x02m3h

266 next x02m4a

267 at 1007

268 write In experiments which require the use of
269 a sinusoidal source, it is generally desirable
270 to use the Audio Oscillator and not the
271 Function Generator because of the Audio Oscillator's
272 purer quality output and greater range.

block 1e, x02m4a

```

274 unit x02m4a
275 join 1mode
276 jump n47,x02m4a,x
277 bare
278 restart
279 back x02m3i
280 next x02m4b
281 at 807
282 write

```

As mentioned before, the Audio Oscillator is normally grounded by the ground link at its terminals.

```

284
285 As you might suspect, it is also possible to operate the Audio Oscillator in its ungrounded or floating mode.

```

```

286 Now prepare the Audio Oscillator for operation
287 in its floating mode by disconnecting its left
288 output terminal from ground.
289 ***

```

```

290 unit x02m4b
291 pack n12,+++++++=+++=+++++++=+++
292 joi cke
293 jump n47,x02m10a,x02m4c
294 ***

```

```

295 unit x02m4c
296 next x02m4d
297 at 1007
298 write

```

With the Audio Oscillator set to operate in its floating mode, it can be connected in series with other generators or the DC SUPPLY. The net output voltage of the series combination would then be the sum of the individual output voltages.

```

303 ***
304 unit x02m4d
305 back x02m4c
306 next x02m4e
307 Help x02s11a
308 at 707
309 write

```

Let's use the Function Generator with the Audio Oscillator in its Floating mode and add a square wave to a sine wave.

```

310
311
312 Connect the adjustable SQUARE output of the Function
313 Generator to one of the terminals of the Audio
314 Oscillator.

```

```

315
316 Then connect the other terminal of the Audio
Oscillator to the A INPUT of the Scope.

```

317 Trigger the Scope from the Function Generator.
318 at 3125
319 write Help is available.
320 ***

321 unit >02m4e
322 pack n33, 0000000000000000000000bc000ba00
323 join cko
324 jump n47, >02m4f
325 pack n33, 0000000000000000000000bc000ba00
326 join cko1
327 jump n47, >02s11a, >02m4f
328 ***

329 unit >02m4f
330 back >02m4d
331 next >02m4g
332 at 1007

333 write Good! Now set the frequency of the Function
334 Generator to 5000 Hz and the frequency of the
335 Audio/Oscillator to twice that frequency.

336 ; Display one period of the square wave on the Scope.
337 ***

338 unit >02m4g
339 pack n33, +e++d(de) (cd) a+ag(1jk) d+(abcd) ++z+<e(pqr) d!(klm) >+
340 join c7dw
341 jump n47, >02m4h
342 pause
343 jump >02m4f
344 ***

345 unit >02m4h
346 back >02m4f
347 next >02m5a
348 at 1007
349 write Notice how turning up the amplitudes of the Function
350 Generator and the Audio Oscillator voltages influences
351 the display of the sum of the two waveforms.

352 Experiment a bit. Change the frequency of the
353 Audio Oscillator and see what happens.

----- part=1, block=f -----

block if, >02m5a

355 unit >02m5a
356 join 1mode
357 jump n47, >02m5a, >02m5a
358 base
359 restart

360 back : x02m4h
361 next : x02m5b
362 zero : n95
363 at : 707

You have seen how the Audio Oscillator and the Function Generator can be used to add two waveforms.

366 As you should have noticed, in that case it is
367 difficult to obtain a stable display because the
368 two frequencies are not synchronized.

369 Let's try a different method to superpose two
370 waveforms.

----- part=1, block=g -----

block 1g, x02m5b

372 unit : x02m5b
373 back : x02m5a
374 next : x02m5c
375 at : 707

376 write You will need the SUPERPOSITION BOARD,
377 ITEM 38. Please get it from the shelf below.

378 The theory for the method you are about to use
379 is based on Kirchhoff's Current Law.

380 The theory states that the current leaving a
381 node is the sum of the currents entering the node.

382 Let me demonstrate this with a few diagrams.

383 ***

384 unit : x02m5c
385 back : x02m5b
386 next : x02m5d
387 at : 407

388 write Below is a node with three branches.

389 The node is labeled A and the branches are
390 labeled 1 through 3.

391 at : 1632
392 write :
393 at : 1613
394 write :
395 at : 1651
396 write :
397 at : 2632
398 write :
399 draw : 251,260;251,105;skip;254,262;400,262;skip
400 : 248,262;102,262
401 at : 1532
402 write : A

```
483 at 1552
484 write 2
485 at 1512
486 write 1
487 at 2732
488 write 3
489 pause
490 mode rewrite
491 at 687
492 write Now let's assume a current reference direction
493 for each branch, and label the diagram accordingly.
494 pause
495 mode rewrite
496 at 1515
497 write i1
498 draw 135,278;174,278;170,282;skip;174,278;170,274
499 at 1548
500 write i2
501 draw 369,278;328,278;332,282;skip;328,278;332,274
502 draw 1835;2235;276,164;skip;272,160;268,164
503 at 2238
504 write i3
505 pause
506 mode rewrite
507 at 687
508 write According to Kirchhoff's Current Law, the current
509 leaving node A is equal to the sum of the currents
510 entering node A.
511 pause
512 mode erase
513 at 687
514 write According to Kirchhoff's Current Law, the current
515 leaving node A is equal to the sum of the currents
516 entering node A.
517 mode write
518 at 687
519 write Therefore i3 is equal to the sum of i1 and i2
520 or i3 = i1 + i2
521 pause 1
522 at 2241
523 write = i1 + i2
524 pause
525 mode erase
526 at 407
527 write Below is a node with three branches.
528
529 write Therefore i3 is equal to the sum of i1 and i2
530 or i3 = i1 + i2
531 mode write
532 at 407
533 write If the currents, i1 and i2, are two waveforms,
534 then i3 will be the sum of the two waveforms.
```

part=1, block=h

* block 1h, x02m5d

457 unit x02m5d
458 back x02m5c
459 next x02m5e
460 at 507
461 write Now that we have reviewed how two currents can be
462 superposed, let's go to the SUPERPOSITION BOARD.
463 ***

464 unit x02m5e
465 back x02m5d
466 erase
467 draw 1314;2514;2552;1352;1314
468 circle 12,132,264
469 circle 11,380,284
470 circle 11,132,131
471 draw 144,283;166,283;166,275
472 draw 153,243;153,210;158,205;148,195;158,185
473 153,180;153,130;skip;143,130;357,130
474 draw 153,243;166,243;166,251
475 draw 357,130;357,180;352,185;362,195;352,205;357,210
476 357,243
477 draw 369,284;347,284;347,276;skip;357,243;347,243
478 347,251
479 draw 288,130;288,134;293,139;283,149;293,159;288,164
480 288,168
481 circle 11,288,179
482 draw 288,189;288,199;skip;283,199;293,199;skip
483 298,199;283,204;293,204;288,199
484 draw 288,204;288,228;skip;278,228;298,228;skip
485 298,233;278,233;skip;288,233;288,286;293,281
486 303,291;313,281;318,286;318,268
487 draw 277,179;259,179;244,204;skip;259,204;279,212
488 288,212
489 draw 259,212;246,240;skip;259,240;259,246;288,246
490 circle 11,245,280
491 draw 288,286;255,286
492 draw 234,286;229,286;224,291;214,281;204,291;199,286
493 199,268
494 draw 166,263;199,263;199,271
495 draw 347,263;318,263;318,268
496 at 1414
497 write 1) R₁ 3 R₂ 5
498 sw1 sw2
499 2 4
500
501 sw4 C
502 7
503 R₄ sw3 Di R₅
504 8
505
506 R₃
507

508 11 SUPERPOSITION BOARD

509 inhibit erase
510 jump n95,x,x02m5f
511 *34

512 unit x02m5f
513 back x02m5e

514 at 307
515 write This is the board you will be using to
516 to superimpose the wave forms.

517
518 This board contains more components than
519 you will need to use for this experiment

520 payse
521 mode erase

522 at 307
523 write This is the board you will be using to
524 to superimpose the wave forms.

525
526 This board contains more components than
527 you will need to use for this experiment

528 mode write
529 at 307

530 write The components that you will not need are
531 the capacitor and the diode. These must be shorted
532 out by closing switches sw3 and sw4 for this experiment.

533 mode erase
534 draw 259,179;244,204;skip;259,212;246,248
535 mode write
536 draw 259,212;259,248;skip;259,179;259,205
537 inhibit erase

----- part=1, block=1 -----

block 11, ~~erase~~

539 unit x02m5g
540 next x02m5h

541 mode erase
542 at 307

543 write The components that you will not need are
544 the capacitor and the diode. These must be shorted
545 out by closing switches sw3 and sw4 for this experiment.

546 mode write
547 at 207

548 write Now, make sure the board is connected to the OGE
549 interface by plugging the board's sensor cable into the
550 jack in the center of the panel below the Function
551 Generator. In addition to closing sw3 and sw4:

552 Set sw1 so that terminals 1 and 2 are connected
553 (sw1 in the up position).

554 Set sw2 so that terminals 5 and 4 are connected.

601 data x02s15a
602 erase
603 pack n33,aacdd8cc+0k0k08c0rd0a08r000k00
604 join ckc
605 jump n47,x,x02m5k
606 calc n95e-1
607 at 1007
608 write You have some errors in your setup.

609 Press -NEXT- to try again.

610 Press -DATA- to see the correct circuit.

611 Press -HELP- to see a list of your errors.
612 ***

613 unit x02m5k
614 back x02m5i
615 next x02m51
616 at 1007
617 write Set the frequency of the Function Generator to
618 5000 Hertz and display two periods of the wave
619 on the Scope.
620 ***

621 unit x02m51
622 pack n33,+f++(cd)(de)+abag(jk)++(abcd)++++++
623 join ckd
624 jump n47,x02s16a,x02m5m
625 ***

626 unit x02m5m
627 back x02m5k
628 next x02m6a
629 at 1007
630 write Experiment with the SUPERPOSITION BOARD for
631 a while if you wish.

632 When you press -NEXT- you will be taken to
633 a short review covering the Audio Oscillator.
634 ***

635 unit x02m6a
636 base
637 restart
638 join imode
639 jump n47,x02m6a,x
640 back x02m5m
641 next x02m6b
642 at 1007
643 write You are ready for a short review covering your
644 experimental examination of the Audio Oscillator.

645 ***

646 unit x02m6b
647 back x02m6a

648 next x02m6c

649 at 607

650 write Set the Audio Oscillator to:

651 Operate at a frequency of about 20,000 Hertz.

652 Be in the nonfloating mode.

653 Generate a peak-to-peak voltage of about 40 volts.

654 ***

655 unit x02m6c

656 calc n51.en51+1

657 pack n33,+++++++=+<d(pq)c(uv)>+,

658 join clkdw

659 jump n47,x,x02m6ca

660 next x02s18a

661 ***

662 unit x02m6ca

663 pack n33,+++++++=+c+a+++++++=+c++

664 join clkdw

665 jump n47,x,x02m6d

666 next x02s18a

667 ***

668 unit x02m6d

669 back x02m6b

670 next x02end

671 at 707

672 write Great!

673 Experiment on your own for a few minutes if you wish.

674 ***

675 unit x02s01a

676 next x02m1b

677 at 1007

678 write The frequency setting of the Audio Oscillator
679 is not quite right.

680 Recall, that the frequency of the generated output
681 is the product of the frequency dial setting and
682 the RANGE dial setting.

683 If the frequency dial is set at 40 and the RANGE
684 dial is set at 200, the generated frequency should
685 be _____ Hz.

686 arrow 1911

687 and 8000.,1

688 end

----- part=1, block=k -----

block 1k, x02s02a

690 unit x02502a
691 next x02502b
692 at 1H07
693 write In order to display a specific waveform on the Scope
694 so the amplitude can be most accurately read:

695 The Y DISPLAY FUNCTION must be set to the pertinent
696 INPUT channel.

697 Recall that every reading from the CRT screen has
698 a possible error of 0.1 cm. Therefore, the calibrated
699 VOLTS FULL SCALE must be set as low as possible in order
700 to give maximum vertical traverse to the displayed
701 waveform.

702 The TIME FULL SCALE of the Scope must be
703 set to display the desired number of periods of
704 the waveform.

705 Press -BACK- if you are ready to proceed,

706 or -

707 press -NEXT- if you need more help on the Time setting.
708 *** -

709 unit x02502b
710 at 507
711 write Let T represent the time duration in seconds of
712 the period of the waveform.

713 One period of a sine wave is shown below.

714 origin 1616
715 axes 0,-100,256,100
716 scales 1
717 scalev 5m
718 latadj 1..25
719 markx 1..π/4
720 write // 1st,1731>T/21st,1748>T
721 write t sin(657) .v5^80.2π..82π
722 at 507

723 write If the frequency of the sine wave is 4000 Hz,
724 the period T of the wave expressed in milliseconds is
725 T = 1000/frequency = _____ ms.

726 arrow 1719
727 again 1728
728 mode rewrite
729 write 1st,2910>Right! and T/2=.125(at,1790).125(at,1747).25(at,1650)msec
730 mode write
731 no
732 end
733 ***

734 unit x02503a
735 next x02503a

736 at 1007
737 write Both the Scope and the Audio Oscillator circuit
738 commons are normally grounded by links on their
739 front panels. Then, in this case, only one connection
740 is required between the ungrounded output of the Audio
741 Oscillator and the INPUT of the Scope.

742 CHECK your connections again.
743 end
744 ***

745 unit x02s04a
746 next x02m2a
747 at 707
748 write Remember that the period (in seconds) of a waveform
749 is the reciprocal of the frequency. $T = 1/f$.

750 To observe only one complete cycle of a waveform;
751 the TIME FULL SCALE of the Scope must be set to
752 one period.

753 Also check the setting of the dials relating to
754 the A channel on the Scope.

----- part=1, block=1 -----

block 11, x02s05a

756 unit x02s05a
757 back v02m2a
758 next v02s05b
759 at 1017
760 write Having problems?

761 Press -BACK- to try again, or,
762 press -NEXT- to see your errors.
763 ***

764 unit x02s05b
765 join ckd2w
766 next n47, x02m2a, x02m2b
767 ***

768 unit x02s06a
769 next x02m3b
770 at 807
771 write Hint!

772 The red adjustable-output jack of the Function
773 Generator is located directly below the red
774 ATTENUATOR knob.

775 Verify that the Audio Oscillator remains
776 connected to the A channel of the Scope.
777 ***

778 unit x02s07a
779 at 807
780 write The frequency of the Function Generator output
781 is the product of the CYCLES/SEC dial setting and
782 the MULTIPLIER dial setting.

783 The black OUTPUT knob selects the shape of
784 the adjustable-output waveform at the red output
785 jack directly below it.

786 The red ATTENUATOR knob controls the amplitude
787 of the waveform at the red output jack. As usual,
788 maximum amplitude is fully clockwise.
789 end
790 ***

791 unit x02s08a
792 next x02m3d
793 at 1007
794 write You had better check your dial settings again.
795 end
796 ***

797 unit x02s09a
798 at 1907
799 write To answer Audio Oscillator, type- a
800 To answer Function Generator, type- b,
801 end
802 ***

803 unit x02s10a
804 next x02m4a
805 at 1007
806 write HINT! The left red output terminal of the Audio
807 Oscillator is normally connected to the black ground
808 terminal by a metal ground link.
809 end
810 ***

811 unit x02s11a
812 next x02s12a
813 at 1007
814 write The Function Generator and the Audio Oscillator
815 should be connected in series, that is they should
816 form a single continuous loop to the Scope.
817 circle 32,152,208
818 draw 1924;1936;2236;2242;2142;skip;304,169;1739;1746
819 , 360,169;304,169;skip;2144;2744;2729;2829;skip
820 , 2933;2633;2614;2914;2933;skip;2831;240,40;skip
821 , 250,40;230,40;skip;235,35;246,35;skip;243,31
822 , 238,31;skip;1916;1912;2012;skip;102,192;74,192
823 , skip;80,186;96,186
824 draw ;skip;92,180;85,180

```
825 at ~129,203
826 write 900PL
827 at ~1940
828 write 8.0.
829 at ~2818
830 write F.G.
831 circle 3,123,176
832 circle 3,344,176
833 circle 3,314,176
834 circle 3,240,64
835 circle 3,224,64
836 inhibit erase
```

part=1, block=m

block 1m. >02s12a

```
838 unit >02s12a
839 next >02m4d
840 mode erase
841 at 1007
842 write The Function Generator and the Audio Oscillator
843 should be connected in series, that is they should
844 form a single continuous loop to the Scope.
845 mode write
846 at 1007
847 write The best source for the external trigger of the
848 Scope is the TRIG OUT of the Function Generator.
849 circle 3,119,64
850 draw 110,04/115,128;155,118;155,176
851 at ~2703
852 write TRIG OUT
853 end
854 at
```

```
855 unit >02s12a
856 back w1noff
857 calc n51e1
858 mode erase
859 at 107
860 write Connect the non-adjustable SQUARE wave output
861 from the Function Generator to terminal 5 and
862 the non-adjustable sine wave output from the
863 Function Generator to terminal 1.
```

Connect the common input of the board (terminal 11) to ground.

Connect the A INPUT of the Scope to Terminal 8 of the SUPERPOSITION BOARD to display the waveform of the total current.

Trigger the Scope from the Function Generator.

```
870 at 2914
871 write Press -HELP- to see a circuit diagram of setup
872 or
873 Press -NEXT- to have your connection checked.
```

874 entry x02s13ae.
875 next x02m5j
876 draw 199,263;166,263;skip;318,263;347,263
877 mode write
878 circle 32,96,448
879 draw 209,228;628,609;209;skip;236;256;656;636;236
880 at 213
881 write SCOPE F. G.
882 draw 199,263;166,275;skip;318,263;347,276
883 circle 3,432,464
884 circle 1,432,441
885 circle 3,166,422
886 circle 3,143,434
887 circle 3,290,461
888 circle 3,383,424
889 draw 287,461;256,461;256,400;166,400;166,419;skip
143,431;143,367;47;367;47,160;144,160
890 circle 6,152,160;180,0
891 draw 160,160;372,160;278,174
892 " skip;435,463;459,463;459,283;390,283;skip
434,440;450,440;450,324;132,324;132,295
895 " skip;383,421;383,346;30,346;80,130;121,130
896 at 318
897 write T.O. SQ
898 A SIN
899 T.I. GRD
900
901 at 2910
902 write After you have made your connections, press -NEXT-
903 end

----- part=1, block=n -----

block in, x02s15a

905 unit x02s14a
906 join* cheiw
907 next x02m5j
908 help x02s15a
909 at 2907
910 write Press -HELP- to see a circuit diagram of the setup

911 or

912 Press -NEXT- to have your connections checked.

913 ***

914 unit x02s15a
915 do x02m5e
916 mode erase
917 draw 259,179;244,204;skip;259,212;246,240
918 mode write
919 draw 259,212;259,240;skip;259,179;259,205

920 mode erase
921 auto >02s13ae
922 end
923 ***

924 unit >02s16a
925 next >02m5k
926 help >02s17a
927 at 1WW7
928 write One or more of your dial settings are wrong.
929
930 Press -NEXT- to have your dials rechecked.
931
or
932 Press -HELP- for a listing of your dial errors.
933 ***

934 unit >02s17a
935 pack n77,+f++(cd)(de)+abag(jk)++(abcd)++++++
936 join okdiw
937 end
938 ***

939 unit >02s18a
940 help >02m4a
941 at 818
942 write You seem to have had difficulty with the review.
943 Press the number you want to do:
944 1. Repeat the review quiz.
945 2. Repeat this experiment.
946 3. Review frequency and amplitude.
947 4. Review floating or grounded operation.
948 arrow 1045
949 long 1
950 store! ni
951 answer (1,2,3,4)
952 jump ni,x,x,>02m6a,>02m8a,>02m1a,>02m4a
953 ***

954 unit >02end
955 back >02m6b
956 join imode
957 jump n47,>02end,x
958 course n2
959 callcc n2='ee244'
960 no(n21+1)≠(nc(n21+1)\$mask\$07777777770000000000)+c4603000000,
961 no(n21+1)≠nc(n21+1)
962 erase
963 output // student has completed experiment ////
964 join endunit
965 join jmpmes

966 jumpout cgeindex,quest_o
 967 entry leave
 968 end lesson
 969 ***
 970 unit endunit
 971 course n2
 972 jump n2#`ee244',leave,x
 973 calc nc(n21+7)+nc(n21+7)+ahelp
 974 vc(n21+6) evc(n21+6)+atime/60000
 975 ***Incl.cge s.r. & TERMS sample,index,imode,comment,slides.
 976 use eex00,cki
 977 use ck2
 978 use ck3
 979 use ck4
 980 use ck5
 981 use ck6
 ckc not found 103 177 292 323 684 560
 ckow not found 664
 ckc1 not found 326
 ckc1w not found 906
 ckd not found 79 108 197 623
 ckdw not found 340 658
 ckd1w not found 936
 ckd2w not found 765
 endunit x02end 970 22 964
 imode not found 32 275 356 638 956
 jmpmes not found 965
 leave x02end 967 972
 x02end x02end 954 670 957
 x02m0a x02m0a 30 33 55 952
 x02mia x02mia 51 35 71 952
 x02m1b x02m0a 70 54 85 676
 x02m1c x02m0a 77 72
 x02m2a x02m0a 82 80 114 735 746 766 757
 x02m2a1 x02m0a 101 86
 x02m2a2 x02m2a2 106 104
 x02m2b x02m2a2 113 111 130 154 766
 x02m2c x02m2a2 129 115
 x02m3a x02m2a2 151 131 165
 x02m3b x02m2a2 164 155 182 769
 x02m3c x02m2a2 175 166
 x02m3d x02m2a2 180 178 201 792
 x02m3e x02m3e 195 183
 x02m3f x02m3e 200 198 219
 x02m3g x02m3e 218 202 241
 x02m3h x02m3e 240 220 265
 x02m3i x02m3e 264 242 279
 x02m4a x02m4a 274 266 276 804 940 952
 x02m4b x02m4a 290 280
 x02m4c x02m4a 295 293 305
 x02m4d x02m4a 304 296 330 839
 x02m4e x02m4a 321 306
 x02m4f x02m4a 329 324 327 343 346
 x02m4g x02m4a 338 331
 x02m4h x02m4a 345 341 360

x02m5a	x02m5a	855	347	357	373	
x02m5b	x02m5b	382	361	385		
x02m5c	x02m5b	384	374	458		
x02m5d	x02m5d	457	386	465		
x02m5e	x02m5d	464	459	513	915	
x02m5f	x02m5d	512	510	858		
x02m5g	x02m5g	539	566			
x02m5h	x02m5g	558	540			
x02m5i	x02m5g	565	562	599	614	
x02m5j	x02m5j	598	563	567	569	875
x02m5k	x02m5j	613	605	627	625	887
x02m5l	x02m5j	621	615			
x02m5m	x02m5j	626	624	640		
x02m6a	x02m5j	635	628	639	647	952
x02m6b	x02m5j	646	641	669	685	
x02m6c	x02m5j	655	648			
x02m6d	x02m5j	662	659			
x02s01a	x02m5j	668	655			
x02s02a	x02m5j	679	680			
x02s02b	x02s02a	689	690	697		
x02s03a	x02s02a	709	691			
x02s04a	x02s02a	734	104			
x02s05a	x02s02a	745	110	111		
x02s05b	x02s05a	756	110	758		
x02s06a	x02s05a	764	110			
x02s07a	x02s05a	768	178			
x02s08a	x02s05a	778	193			
x02s09a	x02s05a	791	198			
x02s09b	x02s05a	797	208	225		
x02s10a	x02s05a	803	293			
x02s11a	x02s05a	811	307	327		
x02s12a	x02s12a	838	812			
x02s13a	x02s12a	855	568			
x02s13e	x02s12a	874	921			
x02s14a	x02end	905	600			
x02s15a	x02end	914	601	908		
x02s16a	x02end	924	624			
x02s17a	x02end	934	926			
x02s18a	x02end	939	660	666		
ahelp		973				
atime		974				
nc		968	968	961	973	973
n1		958	952			
n2		958	959	971	972	
n21		968	968	961	973	973
n23		78	102	107	176	325
		559	603	622	657	663
n47		33	88	104	109	111
		324	327	341	357	562
		665	766	957		634
n51		37	258	252	569	656
n68		36	109	109	109	110
n95		362	510	606		
sin		721				
vc		974	974			
vs7		721	721			
π		717	719	719	721	721

lesson information

lesson name = eex82

starting date = 03/29/73

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by neal of course eecge

at site 7, station 27

author name = J P'Neal

department = EE

telephone number = 333-4351

discipline = EE

grade level = freshman

description of lesson = The Operation and Uses of the Audio Oscillator, HP 200AB.

----- part=1, block=a -----

block 1a, eex03id

2 stop
 3 **** For Neal, CGERL, Room 248 EEB.

4 One line description of this lesson --

5 The Operation and Uses of the Function Generator, Exact 251.

6 Divisions of this Lesson: Block Unit

7 Id for this file	eex03id
8 Experiment eex03;	x03m0a
9 Objectives	x03m0a
10 Measure wave parameters	x03mia
11 Oper. of function generator	x03m2a
12 Development of equi. circuit	x03m3a

13 final edit 21 aug 74 neal.

14 *list info
 15 *list symbols
 16 *list varian,charset,cgeindex,cgechar
 17 ***
 18 start
 19 finish endunit
 20 write . <at,1010> Loading the CGE Character Set
 21 charset cgeindex,cgechar
 22 erase
 23 dataon
 24 area eex03
 25 ext 0

----- part=1, block=b -----

block 1b, x03m0a

27 unit x03m0a
 28 restart
 29 join imode
 30 jump n47,x03m0a,x
 31 at 408
 32 write THE OPERATION AND USES OF THE FUNCTION GENERATOR,
 33 Exact 251.

34 The learning objectives are:

- 35 1) To measure the period, amplitude, and
36 average (dc) characteristics of a waveform;

37 2) To properly drive a two-terminal circuit
38 with any periodic voltage having any adjustable
39 or nonadjustable V_{max} , V_{min} , or V_{av} , and any
40 frequency within the useful limits of the Function
41 Generator, while triggering the Function Generator
42 internally, externally, or manually.

43 3) To experimentally determine a practical
44 equivalent circuit for the Function Generator
45 as seen looking into its nonadjustable SQUARE
46 wave output terminals.

----- part=1, block=c -----

block 1c, x03mia

48 unit x03mia
49 back x03mia
50 calc n51e-1
51 zero n60
52 n61
53 n62
54 n63
55 n64
56 at 1107
57 write Here, you will be given an opportunity to
58 review the physical properties of waveforms (i.e.,
59 V_{p-p} , frequency, period, etc.). You should already be
60 acquainted with these concepts. They will be used
61 extensively in this experiment.
62 ***

63 unit x03mib
64 next x03mfc
65 back x03mia
66 at 1210
67 write From the waveform displayed below, measure
68 the following quantities:
69 join x03s1b
70 at 417
71 write 1) Period _____ sec.

72 2) Frequency _____ Hertz.

73 3) V_{max} _____ volts.

74 4) V_{min} _____ volts.

75 5) V_{p-p} _____ volts.

76 6) V_{g-p} _____ volts.

```

77 **** doto loop avoids repeat questions
78 calc n101+233
79 doto 2line,n100+60,64,1
80 calc n101+n101+200
81 calcs (n100-61),v102+.05,20,20,-20,40
82 calcs (n100-61),v103+1.2,2.0
83 at n101
84 writec n(n100),(z,v102,v103),,
85 2line.
86 join n51,x03s1a,x03s1a1,x03s1a2,x,v03s1a4,x03s1a5
87 ***
```

\$\$ for first use of 10351h

94 at 188
95. write It is often desirable to know other characteristics
96 of a wave in addition to the time - amplitude char-
97 acteristics. One example would be the AVERAGE (DC)
98 value of the wave.

For now, let us concentrate our efforts on SYMMETRICAL waveforms; a later experiment will present a more mathematical approach for finding the average or dc value of any waveform.

part=1, block=d

block id, x03mid

104 unit x03mid
105 next x03m1e
106 help x03s1h
107 back x03m1c
108 at 688
109 write What is the average (dc) value of the symmetric
110 square wave below? _____ volts

-HELP- is available

```
113 join x03sti
114 gdr&w 0,15;10,15;10,-15;20,-15;20,15;30,15;30,-15;30,0
115 arrow 732
116 ansy 0
117
```

```
118 unit x03mle  
119 help x03sij  
120 next x03m2a  
121 back x03mpic  
122 calc n51<20      $$ answers for second call to x03sih.  
123      n52<-10
```

124 n53#5
125 at 608
126 write Now suppose we were to change the average or dc
127 level such that the waveform is symmetrical about
128 a non-zero value. Observe the effect on the wave-
129 form below; what is the average (dc) value ?

130 volts
131
132 -HELP- is available
133 join x03s11
134 gdraw 0,20;10,20;10,-10;20,-10;20,20;30,20;30,0
135 arrow 1126
136 ansv 5
137 ***

----- part=1, block=e -----

block 4a, x03m2a

139 unit x03m2a
140 restart
141 at 907
142 write The Function Generator produces different signals
143 over a continuous range of frequencies. The para-
144 meters of these outputs are adjusted by three
145 groups of dials:

- 146 1) OUTPUT
- 147 2) TIMING
- 148 3) TRIGGERING

149 If you wish to see what any of these groups does,
150 type in the number of that group. If not, just
151 press -NEXT-.

152 pause
153 keytype n70,1,2,3,back
154 jump n70,x03m2b,x03s2a1,x03s2a2,x03s2a3,x03m1d
155 ***

156 unit x03m2b
157 restart
158 base
159 back x03m2a
160 next x03m2c
161 help x03s2b
162 at 1105
163 write Set up the Function Generator for a nonadjustable
164 RAMP Wave having a period of 2 ms.

165 Display this wave on channel A of the SCOPE, using
166 the Function Generator as the trigger source.

-HELP- is available.

----- part=1, block=f -----

block ff. x03m2c

```

169 unit x03m2c
170 zero n62
171      n63
172      n64
173      p65
174      n66
175      n67
176 pack n33,++(op)+(acd)(de)(abcd)a+af(ijk)+++++++
177 join ckd
178 calc n55en47      $$ n55=-1 if dials wrong
179 jump n47,x,x03m2c1
180 pack n33,++++++f(ijk)+++++++
181 join ckd1
182 calc n62en47      $$ n62=-1 if freq. wrong
183 pack n33,+++++(de)+++a+++++++
184 join ckd1
185 calc n63en47      $$ checks trigger
186 pack n33,+++(acd)+(abcd)a+++++++
187 join ckd1      $$ checks dials 5,7,8
188 calc n67en47
189 pack n33,++(op)+++++++
190 join ckd1
191 calc n64en47      $$ n64=-1 if a-volts wrong

192 entry x03m2c1
193 pack n33,0000000000000000n0a000n0a000+00
194 join ckc
195 jump n55,x03s2c,x      $$ falls thru if dials ok
196 jump n47,x03s2c,x03m2d.      $$ x03s2c jumps to helps
197 ***

198 unit x03m2d
199 restart
200 base
201 back x03m2b
202 next x03m2d1
203 help x03s2i
204 at 1407
205 write Now set up the Function Generator for a sine wave
           with a Vp-p = 10 V and having a frequency of 1
           kHz. Trigger the Scope from the Function Generator
           and display the waveform on channel A of the Scope.
206
207
208
209
210 -HELP- is available

```

----- part=1, block=g -----

block 1g, x03m2d1

\$\$ pre-set for use in x03s2j

212 unit x03m2d1
213 zero n60
214 n61
215 n62
216 n63
217 pack n33, ++ (mno) ++ (de) +a+a< f (tuv) g (ab) >b (cdef) +++++++
218 join ckd
219 calc n55en47
220 jump n47, x, x03m2d1e
221 pack n33, ++ (mno) ++++++a+++++b (cdef) +++++++
222 join ckd1
223 calc n60en47
224 pack n33, +++++ (de) +++a+++++*****
225 join ckd1
226 calc n61en47
227 pack n33, ++++++*****< f (tuv) g (ab) >++++++
228 * dial 11 on f and 12 on t,u,v
229 t or dial 11 on g and 12 on a or b

230 join ckd1
231 calc n62en47
232 entry x03m2d1e
233 pack n33, 0000000000000000n00000na000+00
234 join ckd
235 jump n55, x03s2j, x
236 jump n47, x03s2j, x03m2e
237 ***

238 unit x03m2e
239 base
240 help x03s2q
241 back x03m2d
242 restart
243 at 1406
244 write Next set up the system for an adjustable square wave
having a period of 1 ms. with a V_{p-p} of 10 volts. Set
up the Function Generator to be manually triggered
and display the waveform on channel A.
245
246
247
248
249
250 ***

-HELP- is available

251 unit x03m2g
252 zero n60
253 n61
254 pack n33, ++ (mnop) ++ (defg) + (ae) +v< f (tuv) g (ab) >d (abc) +++++++
255 join ckd
256 calc n55en47
257 jump n47, x, x03m2g1
258 pack n33, ++++++**++< f (tuv) g (ab) >++++++
259 join ckd1
260 calc n60en47

```

261 pack n39,++(mnop)+++ (ae) +++++(abc) ++++++++
262 join ckd1
263 calc n61+n47

264 entry x03m2g1
265 pack : n33,00000000000000n0+0000n+000+00
266 join ckc
267 jump n55,x03s2r,x
268 jump. n47,x03s2t,x03m2h
269 ***

270 unit x03m2h
271 restart
272 base
273 help x03s2w
274 back x03m2e
275 at 1206
276 write Finally, set up a 20 Vp-p triangle wave at a frequency
277 of 500 Hz. and a DC LEVEL of -5 volts. Display this
278 waveform on channel A of the scope, which should be
279 triggered from the Function Generator.
280
281 -HELP- is available
282 ***
283 unit x03m2i
284 base
285 zero n60           $$ pre-set for x03s2x
286
287
288 pack n33,++(nop)++(de)c(acd)+af(ijk)c(cde)(st)+++++
289 join ckd1
290 calc n55+n47
291 jump n47,x,x03m2i1
292 pack n33,++++++f(ijk)+++++++
293 join ckd1
294 calc n60+n47
295 pack n33,+++++(de)+++a+++++++
296 join ckd1
297 calc n61+n47

298 entry x03m2i1
299 pack n33,00000000000000n0a0000na000+00
300 join ckc
301 jump n55,x03s2x,x
302 jump n47,x03s2x,x03m3a

```

----- part=1, block=h -----

block 1h, x03m3a

```

304 unit x03m3a
305 base
306 term equiv.

```

```

387 restart
388 join imode
389 jump n47,x03m3a,x
390 back x03m2h
391 at 1205
392 write When you finish this section you should be able to:
393
394 1) Describe and characterize the circuit model of the
395 Function Generator that has been developed.
396
397 2) Establish the applicability of this model to the
398 Function Generator for any given circuit conditions.
399 ***
400
401 unit x03m3b
402 back x03m3a
403 at 006
404 write The Function Generator must be represented by a model
405 consisting of voltage sources, resistors, and other
406 circuit elements useful in circuit theory calculations.
407 A logical first choice would be an IDEAL voltage source
408 as illustrated below.
409 join x03s3a
410 draw 937;1237;284,305;274,301;256,261;261,306;256,301
411 261,296
412 at 1138
413 write iL(t)
414 at 1806
415 write An ideal voltage source, vs(t) is defined as a circuit
416 element whose circuit voltage is a prescribed function
417 of time and is independent of the circuit current. In
418 other words, in the suggested equivalent circuit, vs(t)
419 is independent of iL(t).
420 ***
421
422 unit x03m3c
423 back x03m3b
424 join x03s3a
425 at 1707
426 write vs(t) is the open circuit voltage of the Function
427 Generator. If this were the correct model, would
428 you expect the amplitude or waveshape of the volt-
429 age between points A and B to vary when a resistor
430 is placed across the output? (yes/no)
431 arrow 2410
432 specs nookno,bumpshift
433 match n51, yes, no
434 at 2417
435 write n51, no, no, ok
436 at 2607
437 write The output voltage will not be affected when a
438 resistance is placed across the outputs; it should
439 be independent of the load, as specified.
440 ***
441
442 unit x03m3d
443 back x03m3c

```

361 at 1006
362 write We now have a model of the Function Generator to help
363 us predict its performance in a given circuit applica-
364 tion. Let us now consider a specific case and see how
365 accurately this first model predicts the behavior of
366 the Function Generator.

----- part=1, block=i -----

Block i, x03m3e

368 unit x03m3e
369 next x03s3b
370 back x03m3d
371 at 405
372 write According to Kirchoff's Voltage Law, $V_L = V_S$ on
373 open circuit. Since our model is an ideal voltage
374 source, V_S should not change when a resistor is
375 placed across the output! Let's see if this is
376 the case.
377 join x03s3a
378 draw 841;845;843;942;843;944;843;1043;skip;1243;1443
379 1441;1445
380 at 328,330
381 write V_L
382 at 2107
383 write Set up the Function Generator to produce a non-
384 adjustable square wave at a frequency of .800 hz.
385 Display this waveform on channel A of the Scope
386 and trigger the Scope from the Function Generator.

----- part=1, block=j -----

block i, x03m3f

388 unit x03m3f
389 back x03m3e
390 help x03s3d
391 next x03s3g
392 at 308
393 write Our model predicts that the voltage will not be
394 affected when a resistor is placed across the
395 output.
396 join x03s3a
397 draw 838;296,360;285,353;296,346;285,339;296,332
398 285,325;296,318;296,288
399 at 1708
400 write Using the RESISTOR BOARD, ITEM 32, place a 500 ohm
401 resistor across the output of the Function Generator
402 (nodes A and B) as shown above.

403
404 at 2300
405 write **NOTE: You should still be displaying a non-
406 adjustable square wave at a frequency
407 of 800 Hz.
408
409
410 ***

Press -NEXT- when you have done so.

-HELP- is available

411 unit x03m3g
412 back x03m3f
413 at 1009
414 write Our ideal voltage source model predicted that the
415 voltage would not be affected when a resistor is
416 placed across the output. Can the Function Generator
417 be represented as an ideal voltage source?
418 (yes/no)
419 arrow 1422
420 specs hookno,bumpshift
421 match n51, yes, no
422 at 1431
423 writeec n51, no, no, ok
424 at 1709
425 write An ideal voltage source implies that the voltage
426 will not be affected when a resistor is placed
427 across the output. Hence, the Function Generator
428 cannot be represented by a model consisting only
429 of an ideal voltage source.
430 ***

431 unit x03m3h
432 base
433 next x03m3i
434 back x03m3g
435 at 206
436 write It would appear that the ideal voltage source model
437 for the Function Generator is not adequate.
438 Consider the following model.
439 join x03s3e
440 at 2109
441 write This model consists of an ideal source and an
442 unknown R,L, or C element in series with it.
443 If a resistor were now connected between nodes
444 A and B, V_{AB} would... (increase, decrease, not change)
445 at 2523
446 write
447 arrow 2524
448 specs bumpshift,okextra
449 wrong (increase, not change, not change)
450 draw 2605;2660*
451 at 2709
452 write No. The output would decrease because R_L ($=500\Omega$)
453 and the unknown R,L, or C element would form a
454 voltage divider. Therefore, V_{AB} would be only
455 a fraction of V_s .
456 answer decrease
457 at 2808

458 write Yes, and our earlier observation (V_{AB} decreased)
459 would tend to support this model.

460 endarrow

461 at 3109

462 write ----Hereafter, let us refer to V_{AB} as V_L ----
463 press -NEXT- 1

464 pause

465 join x03m3k1

----- part=1, block=k -----

block 1k, x03m3i

467 unit x03m3i

468 back x03m3h

469 at 1007

470 write We remember that the open circuit voltage of the
471 Function Generator was a square wave. With an R_L of
472 500 ohms connected, is the output still a square
473 wave?

474 (yes/no)

475 arrow 1420

476 specs bumpshift

477 answer yes

478 wrong no

479 at 1607

480 write If the output of the generator doesn't look like
481 a square wave, no conclusions can be made about the
482 unknown elements at this time. However, you should
483 have found that the resistive load did not alter the
484 waveshape and answered "yes" instead of "no".
485 ***

486 unit x03m3j

487 back x03m3i

488 at 1207

489 write The output of the generator with R_L connected is
490 exactly proportional to V_S and would appear to be
491 independent of time. This would lead to the con-
492 clusion that the unknown element has a V/I relation
493 that is independent of time. The only element that
494 satisfies this condition is a _____.

495 arrow 1738

496 specs bumpshift,okspell

497 answer (resistor,resistance)

498 ***

499 unit x03m3k

500 back x03m3j

501 at 407

502 write Can the Function Generator be represented by an ideal
503 source and a resistor if the open circuit voltage is
504 a square wave with a resistor across the output, and
505 the following waveform results? _____ (yes/no)

506 at 1649
507 write time
508 draw 1648;1609;1209;1418;2018;1827;1227;1436;2036;1845
509 1645
510 arrow 740
511 specs nookno,bumpshift
512 match n51, yes, no
513 at 748
514 writec n51, no, no, ok
515 at 2208
516 write Since the output is not a square wave, the relation
517 between V and I is not constant.
518 ***

519 unit x03m31
520 back x03m3k
521 calc n51⁻² \$\$pre-set for x03m3m
522 at 307
523 write A simple equivalent circuit for an actual
524 controlled - source driving a resistive load may
525 be assumed as shown below, where $v_s(t)$ is the
526 voltage of an ideal voltage source and R_g is an
527 internal resistance.
528 join x03s3e1
529 join x03s3k
530 join x03s3f
531 at 2010
532 write where $v_s(t) = v_g(t) + v_L(t) = R_g i_L(t) + R_L i_L(t)$
533
534 or
535
536 $v_s(t) - R_g i_L(t) = R_L i_L(t)$
537 at 2403
538 write Eq. (1)
539 at 2707
540 write We will limit this task to determining experiment-
541 ally whether an equivalent circuit of this type is
542 applicable, and, if so, evaluating R_g .

----- part=1, block=1 -----

block 11, x03m3m

544 unit x03m3m
545 back x03m31
546 add1 n51 \$\$writed in x03s31 and x03s3n
547 join x03s3e1
548 join x03s3k
549 join x03s3f
550 at 2111
551 write In our setup only R_L and V_L are known
552 Noting the given reference direction,
553 write an equation for I_L .
554

555
 556 arrow 2524
 557 specs bumpshift,nooknc
 558 put +/-
 559 $\mu = 1$
 560 $s = s$
 561 $g = g$
 562 storea n60,30
 563 ok
 564 search 'vs',2,n60,30,1,n61
 565 jump n61,x,x03s31
 566 search 'rg',2,n60,30,1,n61
 567 jump n61,x,x03s31
 568 search 'vl/r1',5,n60,30,1,n61
 569 jump n61,x03s3n,x03s3m
 570 ***
 ↴

571 unit x03m3n
 572 base
 573 back x03m3m
 574 calc n5841 \$\$\$\$ used in x03m3p
 575 n514-1
 576 at 500
 577 write In order to experimentally measure a current, I_L ,
 578 with the scope, we measure the voltage, V_L , produced
 579 across a known resistance, R_L , by that current and
 580 calculate
 ↴

$$I_L = \frac{V_L}{R_L}$$

585
 586 Observe I_L with $R_L = 500$ ohms. Is the waveshape of
 587 I_L identical to the waveform you observed for V_S ?
 588 (yes/no)
 589 at 2308
 590 write Is the point at which I_L crosses zero and is positive
 591 occurring at the same point on the display as it was for
 592 V_S ?
 593 (yes/no)

594 specs bumpshift
 595 arrow 1616
 596 answer yes
 597 wrong no
 598 at 1608
 599 write Once again the waveform is a square wave
 600 draw 1808;1848
 601 specs bumpshift
 602 arrow 2616
 603 answer yes
 604 ***
 ↴

605 unit x03m3o
 606 base
 607 back x03m3n
 608 next x03m3p
 609 erase

610 catchup
611 at 505
612 write Eq(1) $v_s(t) - R_g i_L(t) = R_L i_L(t)$
613 at 1007
614 write Excellent, you have now shown that Eq. (1) for the
615 proposed circuit is not violated for the value
616 $R_L = 500$ ohms; in that
617

$$v_s(t) = 500 i_L(t) + R_g i_L(t) = (500 + R_g) i_L(t)$$

618 where R_g may be a positive real number.
619

620 at 1405
621 write Eq(2)
622 at 2207
623 write The above equation could not apply with R_g being a
624 positive real number if the waveshapes of $v_s(t)$ and
625 $i_L(t)$ differed, particularly, if $i_L(t) \neq 0$ when
626 $v_s(t) = 0$.
627

----- part=1, block=m -----

block 1m, x03m3p

629 unit x03m3p
630 inhibit erase
631 lab x03s2e2
632 back x03m3o
633 help x03s3o
634 data x03s3q
635 next x03m3p2
636 at 207
637 write You have not shown that Eq(1) applies for all
638 values of R_L with a specific value of R_g . To do so
639 tabulate V_L p-p and I_L p-p for the specified values
640 of R_L .

641 When you have satisfactorily tabulated values
642 for five different resistive loads, PLATO will plot
643 V_L p-p versus I_L p-p.

$$\text{REMEMBER: } I_L = V_L / R_L$$

644
645 size 2
646 at 1213
647 write Data point no:
648 calc n57+n58-5
649 at 1240
650 showt n58,3
651 size 0
652 at 1412
653 write Choose $R_L =$ _____ (ohms)
654

655 Enter $V_L =$ _____ (Volts) (measured)

656 Enter $I_L =$ _____ (Amps) (calculated)

657
658 at 3222
659

```

660 write -HELP- is available
661 at 1426
662 writec n51,500,1000,250,100,50      $$resistor
663 calcs n51,v130+500,1000,250,100,50
664 calcs n54,v52+17.6,24.5,10.4,4.65,2.55    $$voltage
665 arrow 1623
666 store v131
667 ansy v52,10%
668 no
669 at 2207
670 write Your readings for  $V_L$  must be as accurate as possible.
671 Be sure you are displaying the largest possible
672 waveform on the Scope. Press -LAB- for an explanation.
673 endarrow
674 calc v132+(V131/V130)
675 join x03s3p
676 pause
677 join key=data,x03s3q,x

678 entry x03m3p1
679 next x03m3p2
680 at 1824
681 erase 10
682 catchup
683 at 1822
684 write
685 inhibit erase
686 data x03s3q
687 arrow 1822
688 store v56
689 ansy v132
690 no
691 draw 2803;2862
692 at 2913
693 write I thought I wasn't looking, didn't you? Let's
694 try that division again.  $I_L (=V_L/R_L) = ?$ 
695 endarrow
696 ***

697 unit x03m3p2
698 erase
699 join n58,x,x,x03s3t,x03s3r1
700 add1 n58
701 n51
702 at 1521
703 write Press -NEXT-
704 next n57,x03m3p,x03m3q

```

-- part=1, block=n --

blockn, x03m3q

706 unit x03m3q
707 base

```

708 next x03m3r
709 back x03m3n
710 at' 310
711 write For any range of  $I_L$  where the graph is a straight
712 line, the negative of the value of the slope can
713 be used as the value of  $R_g$  and for that range the
714 assumed equivalent circuit is applicable.
715 origin 100,100
716 axes 300,240
717 scales .08
718 scaley 30
719 labelx .02,.01
720 labely 10,2
721 *size 2
722 graph -.02,20,VL
723 locate .02,-7
724 write  $I_L$  (amps)
725 size 0
726 edraw [v142,v143;v140,v141;v144,v145;v146,v147;v148,v149
727 dots 1line,n100+140,148,2
728 locate v(n100),v(n100+1)
729 write d=(n100-142)/2,500Ω,1000Ω,250Ω,100Ω,50Ω
730 1line
731 locate .045,25
732 write 'slope = - $R_g$ 
733 ***
```

```

734 unit x03m3r
735 next x03end
736 back x03m3g
737 at 409
738 write Thus you have experimentally shown that this
739 circuit is an acceptable equivalent circuit
740 model for the function generator for a range
741 of 0 <  $R_L$  < (≈ 1000) ohms.
742 join x03s3e1
743 at 1624
744 write  $R_g$ 
745 at 2109
746 write where  $R_g$  is the assumed internal resistance of
747 the function generator and  $V_g$  a voltage source.
748 Beyond this range, however, the model is not
749 applicable and other circuit elements must be
750 included to account for variations in the slope
751 of  $V_L/I_L$ .
```

part=2, block-a

block 2a, x03s1a

```

753 unit x03s1a
754 arrow 431
755 store v52
756 ansv .05
```

757 calc n51#0
758 n6#-1
759 no
760 jump x#3sic

761 entry x#3s1a1
762 arrow 631
763 ansv 20
764 calc n51#1
765 n61#-1
766 no
767 jump x#3s1d

768 entry x#3s1a2
769 arrow 831
770 store n54
771 ansv 20
772 calc n51#2
773 n62#-1
774 no
775 jump x#3sic

776 entry x#3s1a3
777 arrow 1031
778 ansv -20
779 calc n51#3
n63#-1
780

781 entry x#3s1a4
782 arrow 1231
783 ansv 40
784 calc n51#4
785 n64#-1
786 no
787 jump x#3s1f

788 entry x#3s1a5
789 arrow 1431
790 ansv 30
791 no
792 jump x#3sic
793 ***

794 unit x#3s1b
795 origin 75,130
796 axes 0,-100,300,100
797 scalex 100
798 scaley 20
799 labelx 25,5
800 labely 10,5
801 gdraw 0,0;12.5,20;37.5,-20;62.5,20;87.5,-20;100,0
802 graph 106,-3,msecs
803 graph -5,23,volts
804 frame -40,-130,375,140
805 ***

806 unit x#3sic

807 next x03m1b
808 back x03m1b
809 at 505
810 write No, the period of this waveform is not $\langle z, v52 \rangle$ secs.
811 Observe the waveform below and, remembering that the
812 period is the time required for the waveform to begin
813 repeating itself, determine the period.
814

815 Note that your answer should be in units of seconds.
816 (1 msec = .001 sec.)
817 join x03s1b
818 ***

819 unit x03s1d
820 next x03m1b
821 at 1005
822 write Now, frequency (f) is the reciprocal of the period (T).
823 You have determined that the period of this waveform
824 is .05 secs. Thus, since $f = 1/T$ and $T = .05$ secs.:
825

$$f = \frac{1}{.05} = 20 \text{ Hz}$$

Press -NEXT- to enter your answer

826 ***
827 unit x03s1e
828 next x03m1b
829 at 806
830 write You incorrectly specified V_{max} as being $\langle z, n54 \rangle$ volts.
831 Observe how V_{max} is noted on the waveform below, then
832 press -NEXT- to enter the correct answer.
833 join x03s1b
834 graph 10,10,V_{max}

835 entry x03s1e1
836 plotaw 21,0;40,20
837 extract 21.0;21.7
838 extract 21.15;21.20
839 ***

840 unit x03s1f
841 next x03m1b
842 at 806
843 write The peak-to-peak value is $V_{max} - V_{min}$. Observe this
844 on the waveform below, then press -NEXT- to enter
845 the correct answer.
846 join x03s1b
847 join x03s1e1
848 graph 21,0;21,-20
849 extract 21,-20;40,-20
850 graph 20,10,V(p-p)

851 unit x03s1g
852 next x03m1b
853 at 987

858 write For this waveform $V(0-p)$ is V_{max} . Observe this on
859 the figure below, then press -NEXT- to enter the
860 correct answer.
861 join x03s1b
862 join x03s1et
863 graph 28,10,V(0-p)

----- part=2, block=b -----

block 2b, x03s1h

865 unit x03s1h
866 join x03s1i
867 gdraw 0,15;10,15;10,-15;20,-15;20,15;30,15;30,-15;30,0

868 entry x03s1hi
869 at 214
870 write Since this is a symmetrical waveform,
871 the average value is the line about which
872 the waveform is symmetrical.

-OR-

...taking a different approach...

$$\frac{V_{max} + V_{min}}{2} = \text{AVERAGE VALUE}$$

Enter $V_{max} = \underline{\hspace{2cm}}$ volts

Enter $V_{min} = \underline{\hspace{2cm}}$ volts

The average value is then $\underline{\hspace{2cm}}$ volts

1028

n51

1028

n52

1442

n53

no

1536

~~(z,n51) + (z,n52)~~ / 2 = 222

2

end

895 unit x03s1i

896 origin 75,150

897 axes 0,-100,300,100

898 scalex 35

899 scaley 20

900 labelx 10,5

901 graph -2,22,Volts

902 graph 38,0,Time

903

904 unit x03s1j

```
985 join x03s1i
986 gdraw 0,20;10,20;10,-10;20,-10;20;20;30,20;30,0
987 join x03s1hi
988 end
989 ***
910 unit x03s2a1
911 next x03m2a
912 output //output help reviewed//
913 at 708
914 write The adjustable output of the Function Generator
915 is affected by:
916
917 1) The Attenuator- The red dial of the OUTPUT
918 group. This dial varies the voltage of the output
919 waveform.
920
921 2) Output Selector- This is the dial behind the
922 attenuator. It is used to select the periodic
923 signal to be controlled.
924
925 3) + DC Level - This dial changes the Vav
926 of the adjustable output.
927
928 4) Terminals- The only terminal affected by the
929 above dials is the one directly below the
930 attenuator. The terminals to the right of the
931 attenuator have a constant magnitude and DC level.
932 end
933 ***
```

```
934 unit x03s2a2
935 next x03m2a
936 output //timing help reviewed//
937 at 1008
938 write The time it takes a periodic signal to complete
939 one cycle is known as the period of the waveform.
940 The number of these periods that occur in one second
941 is known as the frequency of the signal. The Timing
942 section of the Function Generator allows the
943 variation of the signal's frequency. The output
944 frequency is the product of the MULTIPLIER and the
945 CYCLES/SEC dials.
946 end
```

----- part=2, block=c -----

block 2c, x03s2a3

```
948 unit x03s2a3
949 output //trigger reviewed//
950 next x03m2a
951 at 809
952 write To trigger means to initiate or start a cycle.
```

953 This Function Generator has two ways of being
954 triggered. The INT setting causes the generator
955 to be on continuously. The EXT setting allows
956 the Function Generator to be triggered by an
957 external voltage or event. This station is not
958 equipped to externally trigger the Function
959 Generator (% other than manual triggering); thus
960 you should use the INT setting unless you are
961 instructed to do otherwise.

962 The TRIG OUT terminal is used to trigger
963 other instruments synchronously with the
964 Function Generator.

965 end

966 ***

967 unit >#3s2b
968 back >#3m2b
969 at 1107
970 write Remember that $F = 1/T$ where:

971 $F = \text{frequency in Hertz}$

972 $T = \text{period in seconds}$

973 Also, use the output terminal to the right of the
974 attenuator.

975 end

976 ***

977 unit >#3s2c
978 pack n33,00000000000000000000+0000n0+000+00
979 join ck01
980 calc n65en47
981 jump n67,<#3s2e,x
982 jump n65,<#3s2h,x
983 jump n62,<#3s2d,x
984 jump n63,<#3s2g,x
985 jump n64,<#3s2e1,<#3s2g
986 wxy

987 unit >#3s2d
988 next >#3m2c
989 help >#3s2f
990 back >#3m2b
991 at 1105
992 write No, you seem to be having a problem with the timing
993 aspect: You were asked to set it for a period of 2.ms.
994

995 Press -NEXT- if you understand your error and
996 have corrected it.

997 Press -HELP- if you would like some assistance.

998 Press -BACK- to reread the problem statement.

999 ***
1000

1001 unit x03s2e
1002 next x03m2c
1003 back x03m2b
1004 at 705

1005 write Unless you properly set the SWEEP MODE and A
1006 PRE AMP dials, you cannot display this waveform
1007 on the SCOPE. You should have mastered the use
1008 of these dials in the first experiment.

1009 If you need assistance, it would be best for
1010 you to review Experiment 1. (Operation and Use
1011 of the Oscilloscope) before continuing this
1012 experiment.

1013 -OTHERWISE-

1014 Press -NEXT- if you understand your error and
1015 have corrected it.

1016 Press -BACK- to reread the problem statement.

----- part=2, block=d -----

block-d, x03s2e1

1018 unit x03s2e1
1019 back x03m2b
1020 next x03m2c
1021 help x03s2e3
1022 at 805

1023 write The waveform which you are displaying is not acceptable.

1024 Reset the A VOLTS dial so that the waveform is as
1025 large as possible without exceeding the boundaries
1026 of the Oscilloscope screen.

1027 Press -NEXT- when you have correctly set the
1028 A VOLTS dial.

1029 Press -BACK- if you would like to reread the
1030 problem statement.

1031 Press -HELP- for further assistance.

1032 ***
1033 unit x03s2e2
1034 erase \$\$ x03m3p has inhibit-erase
1035 catchup
1036 at 1008
1037 goto ~x03s2e3 \$\$ x03m3p avoids first paragraph
1038 entry x03s2e3
1039 at 605
1040 write At this point of the experiment the size of the

1041 waveform is somewhat of a triviality. However,
1042 the final task of this experiment requires that
1043 you be able to accurately read the peak-to-peak
1044 voltage of the displayed waveform. As you increase
1045 the size of the displayed waveform, your accuracy
1046 improves. The reason for this is as follows:
1047 at 1405

1048 entry x03s2e4
1049 write The normally specified tolerance is $\pm 3\%$
1050 of the FULL SCALE voltage setting. Thus if you are
1051 displaying a 10 volt peak-to-peak signal on a
1052 FULL SCALE setting of 10 volts, you are reading
1053 10 volts $\pm 3\%$, or 10 volts ± 0.3 volts.

1054 Now, suppose you were to decrease the size of
1055 the waveform by changing A VOLTS to 100 VOLTS FULL
1056 SCALE. Once again the tolerance is $\pm 3\%$ or
1057 ± 3 volts. Thus, attempting to read a 10 volt peak-
1058 to-peak signal on a 100 volt FULL SCALE would
1059 produce an answer of 10 volts ± 3 volts, an
1060 unacceptable reading.

1061 end

1062 ***

1063 unit 1 x03s2f
1064 next x03m2c
1065 help x03s2a2
1066 back x03m2b
1067 base
1068 at 605
1069 write You were asked to set the timing dials so as to
1070 obtain a period T of 2 ms.

1071 1 ms (millisecond) = .001 second = 10^{-3} second.

1072 Therefore, T (= 2 ms) = 2×10^{-3} sec.

1073 Frequency f, is the reciprocal of the period; i.e.,
1074 $f = 1/T$

1075 Thus the frequency when T = 2 ms., is

$$f = \frac{1}{2 \times 10^{-3}} = 500 \text{ Hz}$$

1079 at 2205
1080 write Press -HELP- if you would like further assistance.

1081 Press -NEXT- when you have set the timing dials to
1082 500 Hz.

1083 Press -BACK- to reread the problem statement.

----- part=2, block=e -----

block 2e, x03s2g

1085 unit x03s2g
1086 next x03s2g1
1087 at 205
1088 write No, the system is not triggered as requested. Let's
1089 try a different approach.

1090 Beginning with the SCOPE.

1091 Suppose you wish to trigger the SCOPE from another
1092 source, such as the Function Generator, where would
1093 you position the SCOPE's TRIGGER SOURCE dial?

1094 _____ (ext/int)

1095 Now, in order to obtain that external triggering signal,
1096 from the Function Generator which output of the
1097 Function Generator would you connect to the SCOPE's
1098 TRIGGER INPUT ?

1099 _____ (Trig out/ Ext)

1100 arrow 1118
1101 specs bumpshift
1102 answer (ext,external)
1103 wrong (int,internal)
1104 draw 2060;2005;2505;2560;2060
1105 at 2107
1106 write No...
1107 the INT setting triggers the SCOPE internally
1108 internally. You want to trigger the SCOPE externally.
1109 arrow 1618

1110 specs bumpshift,okextra
1111 answer (trig_out,trigout)
1112 draw 2060;2005;2505;2560;2060
1113 at 2107
1114 write Great... Once you have made the connection and/or
1115 dial setting adjustments as specified above you will
1116 have the SCOPE properly triggered. Press -NEXT- when
1117 you have done so.

1118 wrong (ext,external)
1119 draw 2060;2005;2505;2560;2060
1120 at 2108
1121 write No...
1122 The EXT TRIGGER is for externally triggering
1123 the FUNCTION GENERATOR. You want to externally
1124 trigger the SCOPE from the FUNCTION GENERATOR.
1125 ***

1126 unit x03s2g1
1127 back x03m2b
1128 next x03m2c
1129 help x03s2a3
1130 at 508
1131 write Now that you know how to properly trigger the
1132 SCOPE, let's turn our attention to the Function

1133 Generator...
1134
1135 You have already noted that a connection should
1136 be made between the SCOPE's TRIGGER INPUT and
1137 the Function Generator's TRIG OUT. As noted,
1138 this connection allowed the Scope to be triggered
1139 externally. Thus far we have not stabilized the
1140 FUNCTION GENERATOR.
1141 at 1808
1142 write Press -HELP- for a description of how to trigger
1143 the Function Generator.
1144
1145 Press -NEXT- if you know how to properly trigger
1146 the Function Generator and have set
1147 the dials accordingly.
1148
1149 Press -BACK- to reread the problem statement.

----- part=2, block=f -----

block 2f, x03s2h

1151 unit x03s2h
1152 zero n55 \$\$ avoids first jump in x03m2d1
1153 next x03m2c1
1154 back x03m2b
1155 help x03s2hi
1156 at 805
1157 write You are not displaying a nonadjustable RAMP
1158 wave as requested—
1159
1160 Press -NEXT- if you understand your error and
1161 have corrected it.

1162
1163 Press -HELP- for assistance.
1164
1165 Press -BACK- to reread the problem statement.
1166 ***

1167 unit x03s2hi
1168 base
1169 next x03m2c1
1170 lab x03s2a1
1171 at 605
1172 write The nonadjustable RAMP wave output is
1173 located to the right of the OUTPUT dial.

1174 Before changing your set-up, vary the
1175 setting of the ATTENUATOR. You should find
1176 that doing so changes the peak-to-peak value
1177 of the displayed waveform.

1178
1179 Now connect the nonadjustable RAMP wave
1180 output terminal to the SCOPE's a INPUT. You

1181 should now find that varying the ATTENUATOR
1182 setting does not change the peak-to-peak
1183 value of the waveform.
1184
1185 Press -NEXT- when you have connected the
1186 nonadjustable RAMP output to the SCOPE's A INPUT.
1187
1188 Press -LAB- for a further discussion of the
1189 Function Generator's features, output features.
1189 ***

1190 unit : x03s2i
1191 back : x03m2d
1192 at : 1010
1193 write' : Make sure that the OUTPUT selector is
1194 in the SINE wave position. Also be sure the
1195 adjustable OUTPUT terminal is connected to
1196 the SCOPE.
1197 end
1198 ***

1199 unit : x03s2j
1200 pack : n33, 000000000000000n0+00000n+000+00
1201 join : ckl
1202 calc : n63en47
1203 jump : n60, x03s2k, x
1204 jump : n61, x03s2m, x
1205 jump : n62, x03s2l, x
1206 jump : n63, x03s2k, x03s2m
1207 ***

1208 unit : x03s2k
1209 next : x03m2d1
1210 help : x03s2n
1211 back : x03m2d
1212 at : 1009
1213 write : You are not properly displaying an adjustable
1214 SINE wave with a peak-to-peak voltage of 10 volts.

1215 Press -NEXT- if you understand your error and
1216 have corrected it.
1217
1218 Press -HELP- for assistance.
1219
1220 Press -BACK- to reread the problem statement.
1221 ***

1222 unit : x03s2l
1223 next : x03m2d1
1224 help : x03s2p
1225 back : x03m2d
1226 at : 705
1227 write : Caught you day-dreaming a little, right?
1228 Let's set that timing dial at 1000 Hz.
1229
1230

1231 Press -NEXT- when you have done so.
1232
1233 Press -HELP- if you need assistance.
1234 Press -BACK- to reread the problem statement.

part=2, block=g

block 2g, x03s2m:

1236 unit : x03s2m
1237 next : x03m2e
1238 back : x03m2d
1239 at : 1005
1240 write You should still be triggering the SCOPE from the
1241 Function Generator just as you did in the previous
1242 exercise.

1243
1244 Press -NEXT- when you have triggered the SCOPE
1245 from the Function Generator.

1246
1247 Press -BACK- to reread the problem statement.
1248 ***

1249 unit : x03s2n.
1250 base
1251 next : x03s2n1
1252 lab : x03s2a1
1253 at : 811
1254 write The adjustable output terminal is located
1255 directly below the ATTENUATOR dial. Find this
1256 terminal now and connect it to A INPUT on the SCOPE!

1257 Press -NEXT- when you have done so.

1258 Press -LAB- for a further discussion of the
1259 Function Generator's features.
1260 ***

1261 unit : x03s2n1
1262 pack : n33,000000000000+00n0+00000n+000+00
1263 join : ckc
1264 jump : n47,x,x03s2o
1265 pack : n33,000000000000+00n0+00000n+000+00
1266 join : ckciw
1267 pause
1268 jump : x03s2n
1269 ***

1270 unit : x03s2o
1271 next : x03s2o1
1272 back : x03m2d
1273 at : 1005
1274 write Good, now set the OUTPUT selector to the SINE

1275 wave position. Adjust the ATTENUATOR setting until
1276 the peak-to-peak voltage is 10 volts. Of course the
1277 SCOPE's dials should be set so that you can properly
1278 display this waveform on channel A.
1279

1280 Press -NEXT- when you have set these dials correctly.

1281 Press -BACK- to reread the problem statement.
1282 ***

1283 unit x03s2o1
1284 pack n33,++(mno)+++++at+++b(cdef)++++++
1285 join ckd
1286 jump n47,x,x03m2d1
1287 pack n33,++(mno)+++++at+++b(cdef)++++++
1288 join ckd1w
1289 pause
1290 jump x03s2o
1291 ***

1292 unit x03s2p
1293 next x03m2d1
1294 base
1295 at 1108
1296 write ✓ The frequency of the waveform to be displayed is
1297 the product of the settings of the CYCLES/SEC dial
1298 and the MULTIPLIER dial.

1299 Since you want a frequency of 1000 Hz, you should
1300 set the MULTIPLIER dial on 1000 and the CYCLES/SEC
1301 dial on _____

1302
1303 arrow 1716
1304 specs bumpshift
1305 answer (1,one)
1306 At 2RAS
1307 write or.....

1308 You could set the MULTIPLIER dial on 100 and the
1309 CYCLES/SEC dial on _____

1310 arrow 2327
1311 specs bumpshift
1312 answer (10,two)
1313 at 27R9

1314 write Press -NEXT- when you have properly set the
1315 CYCLES/SEC and MULTIPLIER dials at 1000 Hz.

----- part=2, block=h -----

block 2h, x03s2q

1317 unit x03s2q
1318 help x02s3v
1319 back x03m2e

1320 at 1005
1321 write
1322 TRIGGER dial to the MANUAL position.

1323 Also, $f=1/T$ (The frequency of the Function Generator
1324 is the product of the MULTIPLIER and the CYCLES/SEC dials.
1325 at 2005
1326 write If you would like more information on the MANUAL
1327 TRIGGER, press -HELP-. Otherwise, press -NEXT- to
1328 continue.
1329 end
1330 ***

1331 unit x03s2r
1332 jump n60,x03s2s,x
1333 jump ,n61,x03s2t,x03s2u
1334 ***

1335 unit x03s2s
1336 next x03m2g
1337 at 905
1338 write As in the last exercise, you should have a frequency
1339 of 1000 Hz. Set the frequency dials at 1000 Hertz.

1340 Then...
1341 Press -NEXT-
1342 Press -BACK- to reread the problem statement
1343 ***

1344 unit x03s2t
1345 next x03m2g
1346 back x03m2e
1347 at 905
1348 write Once again you are displaying an adjustable wave-
1349 form, this time a 10 V_{p-p} square wave. Carefully,
1350 adjust the ATTENUATOR and check the SCOPE's dial
1351 settings (such as A VOLTS, Y DISPLAY, etc.).
1352
1353 Press -NEXT- when you are properly displaying the
1354 waveform.

1355 Press -BACK- to reread the problem statement.
1356 ***

1357 unit x03s2u
1358 next x03m2g
1359 help x03s2v
1360 back x03m2e
1361 at 811
1362 write You appear to be having trouble with the
1363 manual trigger. Before we go further, you
1364 should be aware that PLATO does not sense when
1365 the MANUAL button is being pressed; thus, it
1366 is not necessary that you be pressing the
1367 MANUAL button when the dial check is in

1368 progress. You only need to have the system
1369 set up to be manually triggered, press the
1370 MANUAL button once or twice to assure your-
1371 self that you have the proper set-up, then:

1372 Press -NEXT- for PLATO to check.

1373 Press -HELP- for further assistance.

1374 Press -BACK- to reread the problem statement.

1375 ***

1376 unit x03s2v
1377 at 605
1378 write When the Function Generator's -TRIGGER selection
1379 dial is set to the EXT position, the Function
1380 Generator may be triggered by an external voltage
1381 or event. Pressing the MANUAL button may be
1382 considered an external event.

1383 You may trigger the SCOPE either internally or
1384 from the Function Generator.
1385 end

----- part=2, block=1 -----

block 21, x03s2w

1387 unit x03s2w
1388 at 1105
1389 write The DC LEVEL control is below the ATTENUATOR.

1390 Carefully set this dial. Also, since this dial
1391 interacts with the ATTENUATOR dial, you may find it
1392 necessary to re-adjust the ATTENUATOR setting.

1393 (Since you are putting a dc component into the
1394 waveform, to what position should the A PRE AMP be set?)
1395 end
1396 ***

1397 unit x03s2x
1398 pack "n33,000000000000000+0a0000+a000+00
1399 join ck01
1400 calc "n62+n47
1401 jump "n60,x03s2y,x
1402 jump n61,x03s2z,x
1403 jump n62,x03s2z,x03s2z1
1404 ***

1405 unit x03s2y
1406 next x03m21
1407 back x03m2h
1408 at 905

1489 write If you've gotten this far, the timing dials should
1490 be causing you problems now. However, the Function
1491 Generator's CYCLES/SEC and MULTIPLIER dials, which
1492 should be set at a frequency of 500 Hz, are not set
1493 properly.

1494 Press -NEXT- when you have set these dials properly.

1495 Press -BACK- to reread the problem statement.

1496 ***

1497 unit x03s2z
1498 next x03m2i
1499 back x03m2h
1500 at 805
1501 write You are not triggering the SCOPE from the Function
1502 Generator.

1503 Press -NEXT- when you have made the necessary dial
1504 and/or connection corrections.

1505 Press -BACK- to reread the problem statement.

1506 ***

1507 unit x03s2z1
1508 next x03m2i
1509 help x03s2z2
1510 back x03m2h
1511 at 905
1512 write You are not displaying a triangle wave with a peak-to-
1513 voltage of 20 volts and a dc level of -5 volts.

1514 Press -NEXT- if you understand your error and
1515 have corrected it.

1516 Press -HELP- for assistance with the DC LEVEL.

1517 Press -BACK- to reread the problem statement.

1518 ***

1519 unit x03s2z2
1520 next x03m2i
1521 at 505
1522 write Before attempting to set the DC LEVEL at -5 Volts,
1523 you must set the 0 Volts level on the SCOPE. To do so,
1524 turn the A PRE AMP to OFF, and position the trace on
1525 the center horizontally by means of the Y POSITION knob.

1526 pause
1527 write Now that you have positioned the zero voltage level
1528 on the SCOPE, do not move the Y POSITION knob. Doing
1529 so will dislocate the zero voltage level on the screen.

1530 Return the A PRE AMP from OFF to its previous setting.

1451 Adjust the Function Generator's DC LEVEL until the
1452 wave is centered about -5 V. Then readjust the
1453 ATTENUATOR and the DC LEVEL as necessary to obtain the
1454 20 V_{p-p} waveform with a dc level of -5 volts.

----- part-2, block j -----

block 2j, x03s3a

1456 unit x03s3a
1457 draw 837;824;1024;1026;1226;1222;1022;1024;skip;1224
1458 1424;1437
1459 at 200,282
1460 write o B
1461 at 288,376
1462 write o A
1463 at 1120
1464 write +
1465 v_g(t)
1466 ***

1467 unit x03s3b
1468 pack n13,++(op)++(de)+a+af(pqr)++++++
1469 join ck.d
1470 jump n47,x,x03s3c
1471 join ckclw /
1472 pause
1473 jump x03m3e
1474 ***

1475 unit x03s3c
1476 pack n13,000000000000+00n0an0000a000+00
1477 join ck.c
1478 jump n47,x,x03m3f
1479 join ckclw
1480 pause
1481 jump x03m3e
1482 ***

1483 unit x03s3d
1484 at 1207
1485 write Connect the (+) output terminal of the Function
1486 Generator to terminal 7 on the RESISTOR BOARD. Also,
1487 connect terminal 7 to (+) A-input of the Scope.
1488

1489 Now connect the (-) output terminal of the
1490 Function Generator to terminal 8 on the resistor
1491 board. Terminal 8 should also be connected to the
1492 A INPUT of the Scope.

1493 end
1494 ***

1495 unit x03s3g
1496 pack n33,++(no)++(de)+a+af(pqr)++++++

1497 join ckd
1490 jump n47,x,x03s3j
1499 pack n33,++ (no) ++++++
1500 join ckd1
1501 jump n47,x03s3h,x03s3j
1502 ***

1503 unit x03s3h
1504 help x03s2e3
1505 next x03s3g
1506 back x03m3f
1507 at 905

1508 write The waveform you are displaying is too small. You
1509 cannot measure it very accurately.

1510 Press -NEXT- when you have reset A VOLTS so that the
1511 waveform is as large as possible without exceeding
1512 the boundaries of the screen.

1513 Press -HELP- for a further explanation.

1514 Press -BACK- to reread the problem statement.
1515 ***

1516 unit x03s3i
1517 next x03s3g
1518 pack n33,++ (no) ++ (de)+a+af (par) ++++++
1519 join ckd1w
1520 ***

1521 unit x03s3j
1522 pack n33,000000ab0000a00b0cb0000c000+00
1523 join ckd
1524 jump n47,x,x03m3g
1525 pack n33,000000ab0000b00a0ca0000c000+00
1526 join ckd1
1527 jump n47,x,x03m3g
1528 join ckd1w
1529 pause
1530 jump x03m3f
1531 ***

1532 unit x03s3l
1533 next x03m3m
1534 at 1315
1535 write $V_g(t)$ and R_g are unknowns. Write your
1536 equation in terms of known parameters
1537 only.

1538 press -NEXT- to try again

1539 at 2111
1540 write n51,,ASK YOUR INSTRUCTOR FOR ASSISTANCE.....
1542 ***

1543 unit x03s3m
1544 next x03m3n
1545 at 1416

1546 write Your equation will work!!

1547

1548

press -NEXT-

1549 ***

1550 unit x03s3n

1551 next x03m3m

1552 at 1615

1553 write No, your equation will not work

1554

1555 press -NEXT- to try again.

1556 at 2411

1557 writec 'MS1,,,ASK YOUR INSTRUCTOR FOR ASSISTANCE.....

----- part-2, block-k -----

block 2k, x03s3e

1559 unit x03s3e

1560 at 1524

1561 write Unknown

1562 R,L,or C

1563 element

1564 at 304,368

1565 write o A

1566 at 304,218

1567 write o B

1568 entry x03s3e1

1569 at 304,368

1570 write o

1571 at 304,218

1572 write o

1573 draw 939;921;1121;1120;1220;1222;1122;1121;skip;1221

1574 1421;1420;1620;1622;1422;1421;skip;1621;1821;1839

1575 at 192,336

1576 write +

1577 at 184,318

1578 write v_s(t)

1579 ***

1580 unit x03s3f

1581 draw 940;1140;320,328;312,320;320,312;312,304;320,296

1582 312,288;320,280;312,272;320,264;312,256;1840

1583 at 1342

1584 write R

1585 draw 1235;1535;1733;1730;238,246;232,240;238,234

1586 at 1436

1587 write I_L

1588 ***

1589 unit x03s3k

1590 at 1416

1591 write

1592 V_g
 1593 +
 1594 at 1624
 1595 write R_g
 1596 entry x03s3ki
 1597 at 308,368
 1598 erase 7
 1599 at 308,218
 1600 erase 7
 1601 draw 945;950;skip;947;1046;947;1048;947;1247;skip
 1602 1447;1847;1845;1850
 1603 at 353,299
 1604 write V_L
 1605 ***
 1606 unit x03s3o
 1607 back x03m3p
 1608 erase
 1609 catchup
 1610 at 1010
 1611 write For each of the five data points place the
 1612 specified value of R_L across the output of
 1613 the Function Generator (just as you have
 1614 done previously). The peak-to-peak voltage
 1615 which you read from the SCOPE is V_L . You
 1616 have already determined that $I_L = V_L/R_L$.
 1617 Since you know V_L and R_L , the calculation
 1618 of I_L is simple division; a calculator has
 1619 been provided for your convenience.
 1620 end
 1621 ***
 1622 unit x03s3p
 1623 draw 2111;2154;2754;2711;2111
 1624 at 2317
 1625 write PLATO CALCULATOR
 1626 at 2312
 1627 write Enter expression such as 5/7, 4.3/75, etc.
 1628 EXPRESSION:
 1629 PLATO CALCULATES:
 1630 at 1904
 1631 write Press -DATA- if you would like to use the calculator to
 1632 calculate I_L . Otherwise press -NEXT- to enter I_L directly.
 1633 ***
 1634 unit x03s3q
 1635 at 1822
 1636 erase 2
 1637 at 2432
 1638 erase 12
 1639 at 2539
 1640 erase 6
 1641 catchup
 1642 inhibit erase
 1643 arrow 2432
 1644 store V_{TA}

1645 ok
1646 endarrow
1647 calc v71@v70
1648 at 2539
1649 show v71
1650 at 2612
1651 write, Press -NEXT- to enter I_L above
1652 pause
1653 jump x03m3p1
1654 ***

1655 unit x03s3r
1656 calc n100@140

1657 entry x03s3r1
1658 calc v(n100)@v56
1659 addi n100
1660 calc v(n100)@v131
1661 addi n100

part=2, block=1

block 21, x03end:

1663 unit x03end.
1664 back x03m3r
1665 join 1mode
1666 jump n47, x03end, x
1667 course n2
1668 calc n2="ee244"
1669 nc(n21+1)@nc(n21+1)\$mask\$07777777700000000000+046030000000
1670 nc(n21+1)@nc(n21+1)
1671 erase
1672 output /// student has completed experiment ///
1673 join i endunit
1674 join jmpmés
1675 jumpout eeindex;questi

1676 entry leave
1677 end lesson
1678 ***

1679 unit endunit
1680 course n2
1681 jump n2="ee244", leave, x
1682 calc nc(n21+7)@nc(n21+7)+ahelp
1683 vc(n21+6)@vc(n21+6)+atime/60000
1684 ***Incl.cge.s.r. & terms sample, index, imode, comment, slides.
1685 use ee@0,ck1
1686 use ck2
1687 use ck3
1688 use ck4
1689 use ck5
1690 use ck6

ckc	not found	194	234	266	1477	300	1523	1263
ckc1	not found	981	1201	1399			1526	
ckc1w	not found	1266	1479		1528			
ckd	not found	177	218	255	1469	289	1497	1285
ckd1	not found	181	184	187	225	190	230	222
		259	262	293		296		1500
ckdw	not found	1288	1471	1519				
endunit	x#3end	1679	19	1673				
imode	not found		29	308	1665			
jmpmes	not found		1674					
leave	/x#3end	1676	1681					
x#3end	x#3end	1663	735	1666				
x#3mia	x#3mia	79	50	49				
x#3mia	x#3mia	40	65					
x#3mia	x#3mia	60	90	887	808	844	820	856
x#3mia	x#3mia	88	64	107	121			
x#3mia	x#3mia	104	89	154				
x#3mia	x#3mia	118	105					
x#3mia	x#3mia	139	120	159	911	935		950
x#3mia	x#3mia	156	154	201	968	1019	992	1066
x#3mia	x#3mia			1127	1154			
x#3m1c	x#3m2c	169	160	990	1002	1020	1029	1064
x#3m1c1	x#3m2c	190	179	1153	1169			
x#3m2d	x#3m2c	198	196	241	1191	1238	1211	1272
x#3m2d1	x#3m2d1	210	202	1209	1223	1286		1293
x#3m2d1e	x#3m2d1	232	220					
x#3m2e	x#3m2d1	236	274	1237	1319	1364	1346	
x#3m2f	x#3m2d1	251	1336	1345	1358			
x#3m2g1	x#3m2d1	264	257					
x#3m2h	x#3m2d1	270	260	310	1407	1419		1430
x#3m2i	x#3m2d1	273	1406	1418	1428	1440		
x#3m2j1	x#3m2d1	276	291					
x#3m2k	x#3mia	307	302	309	321			
x#3m2l	x#3mia	314	341					
x#3m2m	x#3mia	315	360					
x#3m2n	x#3mia	319	370					
x#3m2o	x#3mia	367	389	1473	1481			
x#3m2p	x#3mia	388	410	1478	1506	1530		
x#3m2q	x#3mia	411	434	1524	1527			
x#3m2r	x#3mia	431	466					
x#3m2s	x#3mia	467	435	487				
x#3m2t	x#3mia	486	500					
x#3m2u	x#3mia	495	530					
x#3m2v	x#3mia	510	545					
x#3m2w	x#3mia	544	573	1533	1551			
x#3m2x	x#3mia	571	607	709	1544			
x#3m2y	x#3mia	605	632					
x#3m2z	x#3mia	629	668	704	1607			
x#3m3r	x#3mia	670	1693					
x#3m3t	x#3mia	671	675	679				
x#3m3u	x#3mia	706	704	736				
x#3m3v	x#3mia	734	706	1664				
x#3s1a	x#3s1a	750	86					
x#3s1a1	x#3s1a	761	86					
x#3s1a2	x#3s1a	765	86					
x#3s1a3	x#3s1a	770	86					
x#3s1a4	x#3s1a	781	86					

x03s1a5	x03s1a	788	86				
x03s1b	x03s1a	794	69	817	836	849	861
x03s1c	x03s1a	806	768				
x03s1d	x03s1a	819	767				
x03s1e	x03s1a	830	75				
x03s1e1	x03s1a	838	830	862			
x03s1f	x03s1a	843	787				
x03s1g	x03s1a	855	792				
x03s1h	x03s1h	865	106				
x03s1h1	x03s1h	868	907				
x03s1i	x03s1h	895	113	133	866	905	
x03s1j	x03s1h	904	119				
x03s2a1	x03s1h	910	154	1170	1252		
x03s2a2	x03s1h	934	154	1065			
x03s2a3	x03s2a3	948	154	1129			
x03s2b	x03s2a3	967	161				
x03s2c	x03s2a3	979	195	196			
x03s2d	x03s2a3	989	985				
x03s2e	x03s2a3	1001	983				
x03s2e1	x03s2e1	1018	987				
x03s2e2	x03s2e1	1033	631				
x03s2e3	x03s2e1	1038	1021	1037	1504		
x03s2e4	x03s2e1	1048					
x03s2f	x03s2e1	1063	991				
x03s2g	x03s2g	1085	986	987			
x03s2g1	x03s2g	1126	1086				
x03s2h	x03s2h	1151	984				
x03s2h1	x03s2h	1167	1155				
x03s2i	x03s2h	1190	203				
x03s2j	x03s2h	1199	235	236			
x03s2k	x03s2h	1206	1203	1206			
x03s2l	x03s2h	1222	1205				
x03s2m	x03s2m	1236	1204	1206			
x03s2n	x03s2m	1249	1210	1268			
x03s2n1	x03s2m	1261	1251				
x03s2o	x03s2m	1270	1264	1290			
x03s2o1	x03s2m	1283	1271				
x03s2p	x03s2m	1292	1224				
x03s2q	x03s2q	1317	240				
x03s2r	x03s2q	1331	267				
x03s2s	x03s2q	1335	1332				
x03s2t	x03s2q	1344	268	1333			
x03s2u	x03s2q	1357	1333				
x03s2v	x03s2q	1376	1318	1359			
x03s2w	x03s2w	1387	273				
x03s2x	x03s2w	1397	301	302			
x03s2y	x03s2w	1405	1401				
x03s2z	x03s2w	1417	1402	1403			
x03s2z1	x03s2w	1427	1403				
x03s2z2	x03s2w	1439	1429				
x03s3a	x03s3a	1456	328	342	377	396	
x03s3b	x03s3a	1467	369				
x03s3c	x03s3a	1475	1470				
x03s3d	x03s3a	1483	390				
x03s3e	x03s3e	1559	439				
x03s3e1	x03s3e	1568	528	547	742		
x03s3f	x03s3e	1580	530	549			

x03s3g	x03s3a	1495	391	1505	1517
x03s3h	x03s3a	1503	1501		
x03s3i	x03s3a	1516	1501		
x03s3j	x03s3a	1521	1498		
x03s3k	x03s3e	1589	529	548	
x03s3k1	x03s3e	1596	465		
x03s3l	x03s3a	1532	565	567	
x03s3m	x03s3a	1543	569		
x03s3n	x03s3a	1558	569		
x03s3o	x03s3e	1606	633		
x03s3p	x03s3e	1622	675		
x03s3q	x03s3e	1634	634	677	686
x03s3r	x03s3e	1655	699		
x03s3r4	x03s3e	1657	699		
ahelp		1682			
atime		1683			
data		677			
key		677			
msecs		802			
n		84			
nc		1669	1669	1670	1682
n100		79	81	82	727
		1658	1659	1660	729
n101		78	80	80	728
n2		1667	1668	1680	1656
n21		1669	1669	1670	1682
n33		176	180	183	1683
		227	233	254	1683
		299	980	1200	1683
		1476	1496	1499	1683
n47		30	178	179	1683
		220	223	226	1683
		268	290	291	1683
		1264	1286	1400	1683
		1666			
n51		580	86	91	1541
		514	521	546	421
		764	772	779	664
n52		92	123	886	757
n53		93	124	888	891
n54		770	833		
n55		178	195	219	
n57		649	704		
n58		574	649	651	
n60		51	213	223	
		566	568	758	
n61		52	214	226	
		566	567	568	
p62		53	170	182	
		1400	1403		
n63		54	171	185	
n64		55	172	191	
n65		173	982	984	
n66		174			
n67		175	188	983	
n70		153	154		
		853	853	863	

v	728	728	1658	1660
vc	1683	1683		
volts	803			
v102	81	84		
v103	82	84		
v130	683	674		
v131	666	674	1660	
v132	674	689		
v140	726			
v141	726			
v142	726			
v143	726			
v144	726			
v145	726			
v146	726			
v147	726			
v148	726			
v149	726			
v52	664	667	755	810
v56	608	1658		
v70	1644	1647		
v71	1647	1649		
v7	667			
Time	902			
V	853	863		
Volts	901			
V _{max}	837			
V _L	722			

Lesson information

Lesson name = eex03

starting date = 05/18/73

last edited on 08/21/74 at 11.18.26

by Neal of course eecege

at site 7, station 27

author name = J.P. Neal

department = EE

telephone number = 333-4351

discipline = EE

grade level = Freshman

description of lesson = The Operation and Uses of the Function Generator, Exact 251.

----- part=1, block=a -----

1 block 1a, eex#4id.
 2 stop
 3 **** For Neal, CGERL, Room 248, EEB.

4 One line description of this lesson --

5 The Operation and Uses of the DC Supply, Harrison 865B.

	Block	Unit
6 Divisions of this Lesson:		
7 Id for this file		eex#4id
8 Experiment eex#4;	x#4m0a	x#4m0a
9 Objectives	x#4m0a	x#4m1a
10 Uses of dc supply	x#4m2a	x#4m2a
11 Constant v / constant i opn.	x#4m3a	x#4m3a
12 Operation in floating mode,	x#4m3h	x#4m4a
13 Practical applications	x#4m4d	x#4m5a
14 Optional studies		

15 Final edit 21 aug 74 neal.

16 *list info
 17 *list symbols
 18 *list varian,charset,cgeindex,cgechar
 19 ****
 20 start
 21 finish endunit
 22 write (at,1010) Loading the CGE Character Set
 23 charset cgeindex,cgechar
 24 erase
 25 dataon
 26 area eex#4
 27 ext 0

----- part=1, block=b -----

block 1b, x#4m0a

29 unit x#4m0a
 30 restart
 31 join imode
 32 jump n47,x#4m0a,x
 33 base
 34 next x#4m0b
 35 calc n59*(-1)
 36 at 585
 37 write The Operation and Uses of the Constant Voltage/Constant

38 Current Supply, Harrison Laboratories 865B
39 at 1010
40 write When you have completed this experiment
41 you should be able to:

- 42 1) Determine the cases in which the DC SUPPLY
43 can be used.
- 44 2) Adjust the DC SUPPLY for constant current/
45 voltage operation.
- 46 3) Connect the DC SUPPLY in either a floating
47 or a grounded mode, as the particular application
48 may require.
- 49 4) Use the DC SUPPLY in practical applications.

50 ***

51 unit x04m0b
52 back x04m0a
53 next x04m1a
54 lab x04m4a
55 data x04m5a
56 at 11210
57 write Press -NEXT- for a CGE learning experience,

58 -LAB- if you know all about this device,
59 -DATA- for a do-it-yourself CGE sequence.
60 ***

61 unit x04m1a
62 back n59, x04m0b, x04m3h, x04m5b
63 next n59, x04m1b, x04m3h, x04m5b
64 join n59-3, x04s1a, x
65 goto n59, x, x04s0a, x04s0a, x
66 at 1611
67 write Do you think that this device could be used
68 to generate the 60 Hz. alternating current
69 that is available from wall outlets?

70 arrow 1849
71 answer (n, no, nope; NO, No).
72 at 2211
73 write Right! 60 Hz. current is a periodic function of
74 time.
75 wrong (y, yes, YES, Yes)
76 at 2211
77 write 60 Hz current is not constant, it's a periodic
78 function of time.
79 wrong
80 at 2211
81 write y or n will suffice as an answer.

----- part=1, block=c -----

block 1c, x04m1b

83 unit x04m1b
84 back n59,x04m1a,x04m3h,x04m5b
85 next n59,x04m1c,x04m3h,x04m5b
86 join n59-3,x04s1b,x
87 goto n59,x,x04s0a,x04s0a,x
88 at 1611
89 write Can this supply be used to ...
90 at '811
91 write Generate a constant (dc) voltage of 15 V?
92 Produce 10 volts across a 15 ohm resistor?
93 Generate a constant current of 0.01 amp?
94 arrow 1854
95 answer (YES, Yes, yes, y)
96 wrong (NO, No, no, n, nope)
97 at 2211
98 write Nope, it'll work. Try it!
99 arrow 1954
100 answer (NO, no, No, n)
101 wrong (YES, Yes, yes, y)
102 at 2211
103 write 10 volts / 15 ohms = 0.667 amp. That's too much!
104 arrow 2054
105 answer (no, NO, No, n)
106 wrong (YES, Yes, yes, y)
107 at 2211
108 write 0.01 amp is below the minimum current of 0.1 amp
109 ***

110 unit x04m1c
111 back n59;x04m1b,x04m3h,x04m5b
112 next n59,x04m2a,x04m3h,x04m5b
113 join n59-3,x04s1c,x
114 goto n59,x,x04s0a,x04s0a,x
115 at 1211
116 write The DC SUPPLY should be "ON".
Is the pilot light glowing?
117 arrow 1339
118 answer (yes, y, Yes, YES)
119 wrong (no, NO, No, n)
120 at 1511
121 write Call the lab assistant to check your supply.

----- part #, block=d -----

block 1d, x04m2a

124 unit x04m2a
125 back n59,x04m1c,x04m3g,x04m5b
126 next x04m2b
127 jump n59=3,x04m2b,x

- 128 at 611
129 write The DC SUPPLY will operate as a constant voltage source if the load current remains less than the setting of the CURRENT dial.
130
131 at 1411
132 write Or the DC SUPPLY will operate as a constant current source so long as the load voltage is less than the setting of the VOLTAGE dial.
133 at 1411
134 write In any case, the load current (I_L) will never be greater than the CURRENT dial setting; and, the load voltage, (V_L) will never be greater than the VOLTAGE dial setting. The mode of operation of the DC SUPPLY is determined by the setting of these dials. And the load resistor only! the setting of the METER switch has no effect on this operation!

----- part 1, block e -----

block 1e, 204mch

- 146 unit 204mcb
147 back 204mb
148 next 159, 204mbc, 204mbh, 204mbb, 204mbc
149 prior 159, 204mbc, 204mbh
150 next 204, 204mbb, 204mba, 204mbc
151 at 1411
152 write If the DC SUPPLY is set at 20 volts and 0.15 amps., and then a 100 ohm load is placed in the output, what will be the resultant load current and voltage?
153 at 1411
154 write $I_L = 0.15 \text{ A}$, $V_L = 20 \text{ Volts}$.
155 reason
156 answer 0.15A, 20V
157 at 1411
158 write Right! The DC SUPPLY will not allow the load current to become greater than the dial setting.
159 store 204
160
161 join 205, 0.15, 204mbb, 204mbc
162 assign 204mb
163 answer 159, 1411
164 at 1411
165 write Right, The DC SUPPLY is in constant current mode!
166 reason
167 at 1411
168 write You got I_L right; now just use Ohm's law!
169
170
171
172
173 at 1411
174 write You got I_L right; now just use Ohm's law!
175
176 unit 204mbc

177 help x0432d
178 next x04m2d
179 goto n59, x, x0438a, x0458a, x
180 at 810
181 write Let's try to show this by experimentation.
182 at 1210
183 write Set up the DC SUPPLY for 20 volts and 0.15 amperes.
184 at 3110
185 write -HELP- is available.
186 ***

187 unit x04m2d
188 pack n13, ++++++++(hi) fghijk) +++++
189 join cl d
190 jump! n47, x04s2e, x
191 goto n59-10+n47, x04m3a, x04m3h, x04m5b, x04m5b, x04m5b, x0452

part=1, block=f

block 1 f. x04m3

193 unit >#4m3a
194 back n59,x,x#04m3h,x#04m5b
195 next n59,x#04m3b,x#04m3h,x#04m5b,x#04m3b
196 join #49-3,x#0453a,x
197 get& n59,x,x#0450a,x#0450a,x
198 at 1511
199 write Connect the sensor cable of the RESISTOR BOARD,
200 and then drive the 100 ohm resistor from the
201 DC SUPPLY in the following fashion:

Connect the (+) output to Terminal 3.

Connect the (-) output to GROUND.

204 Connect the (-) output to Terminal 4.

10. *Leucosia* *leucostoma* *leucostoma* *leucostoma* *leucostoma*

207 pack " n3, 00120000000000000000000000120+00
208 join ghe
209. jump n47, x04m3a, x04m3c
210 ***

With the 100 ohm resistor connected the current will not exceed 0.15 amp, at any voltage setting. Also, the voltage will never exceed the 20 volts despite the current setting.

Experiment with this until you can verify these.

228 statements.

229 Can you verify the above?

230 arrow 1642

231 answer (1E7, yes, yes, y)

232 terms no

233 write Call the lab. instructor.

234 join 1mode

235 jump n59-4-n47, x04m3d, x04m3h, x04m5b, x04m3c

----- part=1, block=g -----

block 1g, x04m3d

236 unit x04m3d

237 back n59, x04m3c, x04m3h, x04m5b

238 next n59, x04m3e, x04m3h, x04m5b

239 join n59-1, x04m3b, x

240 goto \n59, x, x04s0a, x04s0a, x

241 stat 2311

242 write If you had as many power supplies of this type
as you wanted could you generate a 1.5 ampere?

243 current ?

244 arrow 2421

245 answer (no, no, no, n)

246 ***

247 unit x04m3e

248 back n59, x04m3d, x04m3h, x04m5b

249 next n59, x04m3f, x04m3h, x04m5b, x04m3f

250 join n59-1, x04m3c, x

251 goto n59, x, x04s0a, x04s0a, x

252 jump n59-3, x04m3f, x

253 ***

254 unit x04m3f

255 back 241-1

256 stat 209

257 write Set the METER dial to display the load current.

258 pause

259 pack n59, ++++++++, ++++++V++++++

260 join chd

261 jump n59-10-n47, x04m3g, x04m3h, x04m5b, x04m5b, x04m5b, x04m3f

262 ***

263 unit x04m3g

264 term test

265 zero n59

266 jump x04m3h

----- part=1, block=h -----

block 1h, x04m3h

262 unit x04m3h

263 at

264 write To review any of these topics press the
265 following keys:

- 266 a) Definitions of direct current (dc).
- 267 b) Power supplies and glowing lights.
- 268 c) Constant voltage and constant current mode.
- 269 d) Power supply load connections.
- 270 e) Multiple power supply operations.
- 271 f) Functions of the METER dial.
- 272 g) Voltage and current limitations.
- 273 h) Operation of the VOLTAGE and CURRENT controls.

274 You will be automatically returned to this
275 page after each review unit.

276 Topic

277 When you are finished press -DATA- for the final test.

278 data x04m4a

279 goto n19,x,y,x04m0a

280 base

281 narrow x04m4

282 long

283 match n08,a,b,c,d,e,f,g,h

284 jump n08,x,x04m1a,x04m1c,x04m2a,x04m3a,x04m3d,x04m3e,x04m1b,x04s2d

285 at 2511

286 write Just type the letter.

287 end

288 unit x04m4a

289 base

290 join 1mode

291 jump n17,x04m4a,x

292 call n08-2

293 display x04m4b

294 end

295 unit x04m4b

296 back x04m1fa

297 at 810

298 write Set the DC SUPPLY to produce the following output:

299 A 15V dc signal across the 500 ohm resistor
300 on the resistor circuit board.

301 The DC voltage generated should be negative
302 (-) with respect to ground.

303 The resistor itself should be connected
304 such that terminal 7 is connected to ground.

305 Set the meter on the DC supply to monitor the

306 load voltage.
 307 pause
 308 pack
 309 join
 310 jump
 311 next
 312 ***
 .
 313 unit >04m4b1
 314 pack n13,++++++*(fg)+++++
 315 join ckd
 316 jump n47,x04s4a,x
 317 jump .04m4c
 318 ***
 .
 319 unit >04m4c
 320 join 100000
 321 jump n47,<04m4c>x
 322 at 511
 323 write Can the power supply be used to generate:
 324 1) A .48 volt dc signal? (yes/no)
 325 2) How about 17 volts ac?
 326 3) A constant current of 0.4 amperes?
 327 arrow 1039
 328 answer (NO, No, no, n)
 329 wrong 1-E5, yes, y, Yes)
 330 >041 n60
 331 answer 1041
 332 answer (NO, No, no, n)
 333 wrong 1-E5, Yes, yes, y)
 334 right n60
 335 wrong 1-E5
 336 answer (1-E5, Yes, yes, y)
 337 next n60, y, y, x04s4d
 338 write (NO, No, no, n)
 339 end n60

part=1, block=1

block 1i. x04m4d

341 unit >04m4d
 342 at 814
 343 write Set the DC SUPPLY to generate 20 V dc
 344 ~ with the current limited to 0.3 A.
 345 Set the METER to measure output voltage.
 346 pause
 347 pack n33,++++++*(hi) (lmn)+++++
 348 join ckd
 349 jump n47,x04s4b,x

158 jump n47, x04s4c, x
159 jump x04m4e
160 end

162 unit x04m4e
164 join 1 mode
165 jump n47, x04m4e, x
166 at 411

167 write If you were to set the dials of the supply to
168 the following positions-

- 169 (1) METER - volts
170 (2) VOLTAGE 20 volts
171 (3) CURRENT 0.1 amperes

172 Would the supply be in constant voltage or
173 constant current operation with a load of
174 10 ohms? (type letter)

- 175 (a) Constant current
176 (b) Constant voltage

177 arrow 1412

178 answer (f), (a)

179 jumping (f), (b)

180 add1 n60

181 ***

182 unit x04m4f

183 at 1119

If you required more current than the DC SUPPLY
could furnish, could you connect two DC SUPPLIES
in parallel?

If you required more voltage than the DC SUPPLY
could furnish, could you connect two DC SUPPLIES
in series?

184 next n60, x04end, x04end, x04s4d

185 arrow 1414

186 answer (f), (g), (h), (n)

187 jumping (f), (g), Yes, (y)

188 add1 n60

189 arrow 1414

190 answer (f), (g), Yes, Yes, (y)

191 jumping (f), (h), (n)

192 add1 n60

193 ***

194 unit x04m5a

195 back x04m5a

196 jump

197 at 620

198 write Do it your self study.

199 at 411

200 writer Choose any method of study you wish!

Enter i for only information
q for only questions, or

b for both information and questions

399 arrow 1411
400 long 1
402 answer f1.i)
403 calc n59#1
404 answer fQ.q)
405 calc n59#3
406 answer 1B,b)
407 calc n59#2
408 ***

409 unit x04m5b
410 back x04m5a
411 base
412 at 611
413 write (Press -BACK- to change study mode.)
414 join x04m2h
415 arrow 2019
416 long 1
417 match n60,a,b,c,d,e,f,g,h,
418 next n60,x,x04m1e,x04m1c,x04m2a,x04m3a,x04m3d,x04m3e,x04m1b

----- part=1, block=j -----

block 1j. x04s0a

420 unit x04s0a
421 * column unit to end goto's
422 ***

423 unit x04s1a
424 at 711
425 write The DC SUPPLY is used to generate direct current; that is, the current (or voltage) generated is constant for a given load, i.e. it is not a periodic function of time.

429 Of course the output of the device is
430 adjustable, but for any setting it will not
431 generate anything but a constant voltage and
432 current, if the load is constant.
433 ***

434 unit x04s1b
435 at 711
436 write Note that this supply can only generate voltages up to 40 volts dc. Also, the maximum current capacity of this supply is 0.5 amperes. Voltages or currents greater than these limits cannot be produced.

440
441 However, the supply will not operate at all if
442 the CURRENT dial is set less than about 0.1 amp.
443 ***

445 unit x04s1c
446 at 811
447 write * Turn on the DC SUPPLY by throwing the
448 small toggle switch on the left of the supply.
449 The small red pilot light should glow.
450 ***

451 unit x04s2a
452 at 611
453 write Calculating I_L and V_L is easy. Just assume that
454 the supply is in either constant voltage or
455 constant current operation. Then, use R_L to
456 calculate the remaining V_L or I_L . If the V or
457 I is not greater than its limit, you have the
458 solution. If not, the supply is operating in
459 the other mode.
460 ***

461 unit x04s2b
462 at 611
463 write I_L cannot be greater than the current limit.
464 ***

465 unit x04s2c
466 at 611
467 write No, if I_L were really that, what would V_L be?
468 find which parameter (I or V) would be limiting?

part=1, block=k

block 1k, x04s2d

470 unit x04s2d
471 back n59, x04m2c, x04m3h, x04m5b
472 next n59, x04s2d2, x04m3h, x04m5b, x04s2d2, x04m5b
473 join n59-3, x04s2d1, x
474 goto n59-1, x04s2d1a, x04s2d1a, x
475 jump n59-3, x04s2d2, x
476 ***

477 unit x04s2d1
478 at 810
479 write To set the power supply to a given voltage and
480 current limit output, first short the + (red)
481 and - (black) terminals of the DC SUPPLY
482 with a test lead.

483 With the METER switch on AMPS, adjust the
484 CURRENT control to the desired current limit.

485 Remove the test lead from the DC SUPPLY
486 terminals and turn the METER switch to VOLTS.
487 Then adjust the VOLTAGE control to the desired

488 output voltage limit.

489 One additional note: Be sure you are reading
490 the correct meter scale when setting the
491 current and voltage limits.

492 ***

493 unit x04s2d2
494 back n59-3, x04s2d, x04m5b
495 next n59, x04m2c, x04m3h, x04m5b
496 at 410

497 write To set the output current limit of the DC SUPPLY,
498 which of the following is necessary?

500 a) The + output terminal of the supply should
501 be grounded.

502 b) The + and - terminals of the supply should
503 be shorted together.

504 c) The + and - terminals of the supply should
505 be left open circuited.

506 arrow .1520

507 specs nockno

508 answer (b,BK)

509 at 1705

510 write Right! But, remember to disconnect the short when
511 setting the output voltage limit.

512 wrong (a,A)

513 at 1705

514 write No! The DC SUPPLY is a floating supply and hence
515 neither the + or - terminals are internally
516 connected to ground.

517 answer (c,C)

518 at 1705

519 write No! Only when you are setting the voltage limit
520 is it necessary that the output terminals be
521 open circuited.

522 at 1705

523 write Just type the letter of your response.

524 ***

525 unit x04s2e
526 next x04m2c
527 pack n58, ++++++ij++++
528 join ckd1
529 jump n47, x04s2f, x1
530 at 1716

531 write You are reading the wrong meter scale!!

532 at 1716

533 unit x04s2f
534 next x04s2d
535 at 1705

536 write You have incorrectly set the VOLTAGE and/or
537 CURRENT dials. You will receive help when you

538

you press -NEXT-.

----- part=1, block=1 -----

block 11, x0453a

540 unit : x0453a

541 at : 811

542 write . The output of the DC SUPPLY is available
543 at the red and black jacks in the lower right
544 area of the panel. The silver jack at the far
545 right is a chassis ground and may be connected
546 to either the red or black jack as required.
547 ***

548 unit : x0453b

549 at : 811

550 write Note carefully that two DC SUPPLIES cannot
551 be connected in parallel to achieve a greater
552 current capability. The reason for this is
553 simple but important:

554 If two DC SUPPLIES are connected in parallel,
555 one supply will try to drive the other and a
556 large current will flow along the low resistance
557 wires between the supplies. This does not
558 happen when two DC SUPPLIES are connected in series
559 with a current limiting load; thus, they can be
560 connected in series to generate larger voltages
561 than either supply acting alone.
562 ***

563 unit : x0453c

564 at : 811

565 write Note the METER switch located just right of
566 the panel meter. This switch controls the
567 indications of the meter. The meter will
568 measure either load current or load voltage,
569 depending upon the position of the switch.

570 Note that this switch has NO EFFECT on the
571 operation of the supply, it simply indicates the
572 actual terminal voltage or current.
573 ***

574 unit : x045.4a

575 at : 1111

576 write Remember...

577 Set the output voltage to 15 V dc.

578 (It will be necessary for you to increase
579 the output current limit until the voltage
580 across the 500 ohm resistor is 15 V dc.)

581 next Monitor the output voltage!
582 x04m4a
583 ***

584 unit x04s4b
585 pack n33, ++++++++=a(ijk)q+++++
586 join ckd1
587 jump n47, x04s4c, x
588 at i116
589 write You are reading the wrong meter scale!!
590 next x04m4d
591 ***

592 unit x04s4c
593 jpin x04s2f
594 pause
595 erase
596 join x04s2d1
597 pause
598 jump x04m4d

----- part=1, block=m -----

block 1m, x04end

600 unit x04s4d
601 at 1211
602 write You appear to be having some trouble.
603 Press -NEXT- for a chance to review.
604 c A student failing the prof. test has (n59+1).
605 next n59, x04m5a, x04m3h, x04m5a
606 ***

607 unit x04end
608 back x04m5a
609 join imode
610 jump n47, x04end, x
611 course n2
612 calc n2=lee244,
613 nc(n21+1)+(nc(n21+1)\$mask\$07777777770000000000)+046030000000,
614 nc(n21+1)eng(m21+1)
615 erase
616 output /// student has completed experiment ///
617 join endunit
618 join jmpmes
619 jumpout cgeindex,quest1

620 entry leave
621 end lesson
622 ***

623 unit endunit

624 course n2
 625 jump n2='ee244', leave, x
 626 calc nc(n21+7) & nc(n21+7) +ahelp
 627 vc(n21+6) & vc(n21+6) +atime/60000
 628 ***Incl.cge s.r. & terms sample, index, imode, comment, slides.
 629 use eex00, ck1
 630 use ck2
 631 use ck3
 632 use ck4
 633 use ck5
 634 use ck6

ck0	not found	208				
ckcw	not found	309				
~ckd	not found	189	254	315	348	
ckd1	not found	528	586			
endunit	x04end	623	21	617		
imode	not found	31	226	290	320	609 354
jmpmes	not found	618				
leave	x04end	620	625			
x04end	x04end	607	380	380	610	
x04m0a	x04m0a	29	32	52	296	391
x04m0b	x04m0a	51	34	62		
x04m1a	x04m0a	61	55	84	284	418
x04m1b	x04m1b	83	63	111	284	418
x04m1c	x04m1b	110	85	125	284	418
x04m2a	x04m2a	124	112	147	284	418
x04m2b	x04m2b	146	126	127		
x04m2c	x04m2b	176	148	148	471	495 526
x04m2d	x04m2b	187	178			
x04m3a	x04m3a	193	191	209	212	212 418 284
x04m3b	x04m3a	206	195	195		
x04m3c	x04m3a	211	229	227	230	
x04m3d	x04m3d	229	213	227	242	284 418
x04m3e	x04m3d	241	231	249	284	418
x04m3f	x04m3d	248	243	243	246	255
x04m3g	x04m3d	257	125	255		
x04m3h	x04m3h	262	62	63	84 112	85 149 111
			191	194	195 227	212 234 213
			231	242	243 414	255 471 260
			472	495	605	
x04m4a	x04m3h	288	54	278	291	582
x04m4b	x04m3h	295	243	311		
x04m4b1	x04m3h	313	318			
x04m4c	x04m3h	319	317	321		
x04m4d	x04m4d	341	590	598		
x04m4e	x04m4d	353	851	355		
x04m4f	x04m4d	372				
x04m5a	x04m4d	390	55	410	605	605 608
x04m5b	x04m4d	409	62	63	84 112	85 125 111
			148	191	191 425	191 213 194
			227	230	231 255	242 255 243
			295	471	472	472 495 494
x04s0a	x04s0a	420	65	65	87 114	87 154 114
			150	179	179 203	197 233 197
x04s1a	x04s0a	423	64			
x04s1b	x04s0a	434	86			

x04s1c	x04s0a	445	113			
x04s2a	x04s0a	451	149			
x04s2b	x04s0a	461	166			
x04s2c	x04s0a	465	166			
x04s2d	x04s2d	470	177	284	494	534
x04s2d1	x04s2d	477	473	596		
x04s2d2	x04s2d	493	472	472	475	
x04s2e	x04s2d	525	198			
x04s2f	x04s2d	533	191	529	593	
x04s3a	x04s3a	540	196			
x04s3b	x04s3a	548	232			
x04s3c	x04s3a	563	244			
x04s4a	x04s3a	574	316			
x04s4b	x04s3a	584	349			
x04s4c	x04s3a	592	350	587		
x04s4d	x04end	600	337	388		
ahelp		626				
atime		627				
no		613	613	614	626	626
n2		611	612	624	625	
n21		613	613	614	614	626
n33		188	207	253	308	314
n47		32	190	191	209	227
		321	349	350	355	529
n59		35	62	63	64	65
		111	112	113	114	125
		179	191	194	195	196
		230	231	232	233	242
		255	259	279	403	405
		474	475	494	495	605
n60		283	284	292	330	334
		384	388	417	418	
yo		627	627			
v55		164	166	171		
%		160				

lesson information

lesson name = eex04

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by neal of course eecege

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discipline = EE

grade level = Freshman

description of lesson = The Operation and Uses of the DC Supply, Harrison 865B.

----- (part=1, block=a) -----

block 1a, eex05id

2 stop
3 *** For Neal, CGERL, Room 248, EEB.

4 One line description of this lesson --

5 The Operation and Uses of the Vacuum Tube Voltmeter, HP4000D.

6 Divisions of this Lesson:

Block Unit

7	Id for this file	eex05id
8	Experiment eex05;	
9	Objectives	
10	Properly set range dial	x05m0a
11	Properly connect vtvm	x05m1a
12	Determine uses of vtvm	x05m1a
13	Convert rms to p-p	x05m2d
14	Predict vtvm indications	x05m3a
15	Final test	x05m4a
		x05m5h
		x05m6a

16 Final edit 21 aug 74 neal.

```

17 *list info
18 *list symbols
19 *list varian,charset,cgeindex,cgechar
20 ****
21 start
22 finish endunit.
23 write {at,1010} Loading the CGE Character Set
24 charset cgeindex,cgechar
25 erase
26 dataon
27 area eex05
28 ext .0
29 ***
30 unit x05m0a
31 base
32 restart
33 next x05m1a
34 join imode
35 jump n47,x05m0a,x
36 at 507
37 write THE OPERATION AND USES OF THE VACUUM TUBE VOLTMETER,
38 Hewlett Packard Model 4000D

```

39 In this experiment, you should learn to:

40 1) Adjust the RANGE dial of the VTVM to measure
41 voltages accurately.

- 42 2) Properly connect the VTVM to the terminal
 43 whose voltage-to-ground is to be measured.
- 44 3) Determine those voltages which can and cannot
 45 be accurately measured on the VTVM.
- 46 4) Convert V_{rms} to V_{pp} , and understand the
 47 relationship between the two for sinusoidal waveforms.
- 48 5) Predict the VTVM indication for simple
 49 non-sinusoidal periodic waveforms.

----- part=1, block=b -----

block 1b, x05m1a

51 unit x05m1a
 52 back x05m0a
 53 next x05m1b
 54 at 51.0

55 write Voltage measurements are displayed on the
 56 large panel meter. The RANGE switch (below the
 57 meter) is used to scale the input voltage to
 58 allow more accurate readings.

59 The setting of the RANGE switch determines the
 60 largest rms voltage voltage that can be measured
 61 at that setting. For most accurate measurements,
 62 the pointer should indicate in the range between
 63 30 to 100 % of full scale.

64 ***

65 unit x05m1b
 66 back x05m1a
 67 next x05m1b1
 68 help x05s1a
 69 at 1010

70 write Set the RANGE dial to accurately measure a
 71 45 rms volt signal.

72 -HELP- is available.
 73 ***

74 unit x05m1b1
 75 help x05s1a
 76 pack n33, ++++++++, ++++++++, k+
 77 join ckdw
 78 jump n47; x, x05m2a
 79 next x05m1b
 80 ***

81 unit x05m2a

82 back x05m1b
83 next x05m2b
84 at 510
85 write The voltage applied between the RED and BLACK
86 jacks on the left side of the voltmeter marked
87 INPUT is the voltage that will be measured by
88 the voltmeter. The BLACK jack is internally
89 connected to ground. The RED jack is connected
90 to the point of interest. Note that the
91 resultant voltage is always measured with
92 respect to ground, because the BLACK jack is
93 internally grounded.
94 ***

95 unit x05m2b
96 back x05m2a
97 next x05m2c
98 at 1810
99 write If you were to measure a voltage with respect
100 to ground at some point "X", which color terminal
101 on the VTVM would you connect to "X"?
102 arrow
103 specs
104 answer red
105 at 2010
106 write

RIGHT ! And that's the only connection required.

However, if you were to measure a voltage in an
UNGROUNDED circuit you would have to connect the
black terminal of the VTVM to the circuit also.

110 wrong black
111 at 1810
112 write The black jack is already connected to ground.
113 no
114 at 1810
115 write You only need to write the color of the jack.
116 ***

117 unit x05m2c
118 back x05m2b
119 next x05m2d
120 at 510
121 write Connect the VTVM to display an indication for
122 the 0.1V P-P CAL OUT jack on the SCOPE.

----- part-1, block=c -----

block 1c, x05

124 unit x05m2d
125 back x05m2c
126 next x05m3a
127 help x05s1a
128 at 510

129 write Adjust the RANGE switch to accurately measure
130 the output from the 0.1V P-P CAL OUT' jack.

131 . What indication do you read ?

132 at 1429

133 write -HELP- is available

134 arrow 843

135 specs nookno ..

136 ansy 0.056,.002

137 at 1015

138 write Excellent ! A very close reading:

139 ansy 0.056,.01

140 at 1015

141 write That's a good reading.

142 wrongy 0.056,.04

143 at 1015

144 write Try to get a little closer reading.

145 wrongy 0.0056,.001

146 at 1015

147 write You've got the wrong jack !

148 no

149 at 1015

150 write You're way off, better try again.

151 ***

152 unit x05m3a

153 back x05m2d

154 next x05m4a

155 at 305

156 write The nonsinusoidal voltage from the SCOPE that you just measured was at a frequency of 1000 Hz. Furthermore, the scale reading was equal to or less than the voltage label.

159 Only frequencies greater than 10 Hz but less than
160 4 MHz (4×10^6) can be measured accurately.

161 Also, only indications larger than about 0.001 and
162 less than 300 can be read accurately.

163 at 1508

164 write Can the VTVM be used to measure:

165 1) A .17 V p-p 1000 Hz signal ? (yes/no)

166 2) The 115 volt ac output of a wall receptacle ?

167 3) A 43 volt dc signal ?

168 arrow 1739

169 specs bumpshift

170 answer yes

171 arrow 1957

172 specs bumpshift

173 answer yes

174 arrow 2133

175 specs bumpshift

176 answer no

177 no

178 at 2422

179 write REMEMBER: dc is 0 Hz.
180 ***

181 unit x05m4a

182 restart

183 base

184 join imode

185 jump n47, x05m4a,x

186 at 507

187 write This task will examine the relationship between
188 the peak-to-peak voltage measurement on the SCOPE,
189 and the R.M.S. SINE indication on the VTVM, for the
190 same ac signal.

191 In electrical engineering, the term ac for
192 alternating current usually refers to a sinusoidal
193 current with a zero average value.

194 To begin our experiment, we need an ac source.
195 Hence, set the AUDIO OSCILLATOR to an output frequency
196 of 2000 Hz.

197 pause

198 jump key=back, x05m3a,x

199 entry x05m4a1

200 pack n33, +++++++<b (uy) c lbc >+

201 join ckd

202 jump n47, x05s4a, x05m4b

203 ***

204 unit x05m4b

205 at 1007

206 write Measure this signal with the VTVM, as follows:

207 First, set the VTVM range to allow the most accurate
208 measurement of a 25 rms volt sinusoidal signal.

209 pause

210 jump key=back, x05m4a,x

211 pack n33, +++++++<+>

212 join ckd

213 jump n47, x05s4b, x05m4c

----- part=1, block=d -----

block 1d, x05m4c

215 unit x05m4c

216 at 510

217 write Connect the output of the AUDIO OSCILLATOR
218 to the VTVM.

219 The VTVM is internally grounded and only
220 requires one connection.

221 Be sure that the AUDIO OSCILLATOR ground link
222 is connected and tightened.
223 pause
224 jump key-back, x05m4b, x
225 pack n33, 00000000000000000000000000000000aba
226 join ckw
227 jump n47, x, x05m4d
228 next x05m4c
229 ***

230 unit x05m4d
231 back x05m4c
232 next x05m4d1
233 at 510
234 write Carefully adjust the output AMPLITUDE of the
235 AUDIO OSCILLATOR to cause a 25 rms volt indication
236 on the VTVM.
237 ***

238 unit x05m4d1
239 pack n33, +++++++*(rs) (bc) (bcuv)
240 join ckd
241 jump n47, x, x05m4e
242 pack n33, +++++++*(tu) (bc) (bcuv) j
243 join ckd1
244 goto n47, x, x05m4c
245 pack n33, +++++++*(pg) (bc) (bcuv) j
246 join ckd1
247 goto n47, x, x05m4d
248 at 510
249 write You're way off! The frequency should still
250 be 2000 Hz. The VTVM should be set to measure
251 25 RMS volts. The Audio Oscillator AMPLITUDE
252 should be adjusted to cause an indication of
253 25 rms volts on the VTVM.
254 pause
255 jump x05m4d1
256 ***

257 unit x05m4e
258 back x05m4d
259 next x05m4f
260 erase
261 catchup
262 at 1510
263 write Now that you have set the AUDIO OSCILLATOR
264 correctly, do not change any of its controls unless
265 specifically directed.
266 ***

267 unit x05m4f
268 back x05m4e
269 next x05m4g
270 at 510
271 write The ac voltage you have set is measured
272 on the VTVM in rms (root-mean-square) volts.

273 Ropt-mean-square volts are defined as follows:
274 at 1819
275 write $V_{rms} = \left[(1/T) \int_0^T (v(t))^2 dt \right]^{1/2}$

276 at 1210
277 write where T = the period of v(t), and v(t) is in volts.
278 pause

279 at 1410
280 write Note that root-mean-square is descriptive
281 of the above formula, as follows:

282 ROOT = square root of the bracketed expression

283 MEAN = $1/T \times \int_0^T (v(t)) dt$ of the following integrand

284 SQUARE = squared time function = $(v(t))^2$

285 ***

286 unit x05m4g
287 back x05m4f
288 at 710

289 write Set the SCOPE to measure an ac voltage on the A
290 channel with A VOLTS at 100 V FULL SCALE.

291 Of course, the A PREAMP should be AC coupled and
292 the SWEEP should be internally triggered by AC signals.

293 RECALL: DO NOT TOUCH THE AUDIO OSCILLATOR DIALS!

294 pause
295 pack n33, f4p++f+ab++++++
296 join ckd
297 jump n47, x05s4e, x05m4h

----- part=1, block=e -----

block 1e, x05m4h

299 unit x05m4h
300 at 710
301 write Connect the output of the AUDIO OSCILLATOR
302 to the A INPUT of the SCOPE.

303 The SCOPE is grounded by ground links and also
304 requires only one connection.

305 pause
306 pack n33, 00000000000000000000000000ba+0
307 join ckew
308 jump n47, x, x05m4i
309 next x05m4h
310 ***

311 unit x05m4i
312 base x05m4e
313 back

```

314 next x05m5a
315 calc n120#-1
316 at 510
317 write What is Vpp (from the SCOPE)? _____ volts
318 arrow 540
319 store v55
320 ansv 70,4
321 endarrow
322 calc v56#25.0/v55
323 at x 710
324 write On the basis of your measurements:
325 Vrms = _____ * Vpp
326 join x05s4f
327 entry x05m4i1
328 inhibit erase
329 data x05s4f
330 back x05m4e
331 arrow x 920
332 ansv v56,18%
333 no
334 at x 1110
335 write Vrms = VTVM indication = 25
336
337 Vpp = Scope Reading ÷ (s,v55) volts
338
339 Vrms = 22 * Vpp
340
341 Press -NEXT- to clear your answer; then...
342 ...Press -DATA- to re-use the calculator.
343 endarrow
344 calc n120#0
345 at 1110
346 write And Vpp = _____ * Vrms
347 join x05s4f
348 entry x05m4i2
349 inhibit erase
350 data x05s4f
351 back x05m4e
352 arrow 1120
353 ansv v56#25,2%
354 no
355 at x 1315
356 write Press -NEXT- to clear your answer then ...
357 ... press -DATA- to re-use the calculator
358 endarrow
359 at x 1310
360 write NOTE: These conversion factors are only valid
361 for a sinusoidal wave symmetric about 0 volts.
362
363 Let's take a look at what the theoretical values
364 are for these conversion factors.
365 ***
366 unit x05m5a

```

367 term rms
368 back x05m4i
369 next x05m5b
370 erase
371 catchup
372 at .219
373 write | NOTE: Study this sequence carefully.
374 You'll be asked a problem based on this method.
375 at .715
376 write Consider an ac or simple sine wave:

377 v(t) = sin(wt)
378 join x05s5b
379 delta .1
380 funct (sin(v55)),v55
381 ***

382 unit x05m5b
383 back x05m5a
384 next x05m5c
385 at .305
386 write Now let's square v(t):

387 (v(t))^2 = ('sin(wt)')^2
388 join x05s5b
389 delta .1
390 funct (sin(v55))^2,v55
391 pause

392 join x05s5b1
393 pause
394 calc v60=sqrt(v59)
395 at .2219
396 write $V_{rms} = \sqrt{V_1} = 42, V_{60}, 3.3$
397 hbar 2π,.707,
398 graph 2.1π,.707,V_{rms}
399 pause
400 at .2505

401 write The average of the squared wave is 0.5

402 The square root of 0.5 is 0.707

403 The value of $V_{rms} = 0.707$ for $v(t) = \sin wt$ compares
404 with $V_{pp} = 2.0$ which is read on the Scope for $v(t)$.

----- part=1, block=f -----

block 1f, x05m5c

406 unit x05m5c
407 back x05m5b
408 next x05m5d
409 at .709
410 write Generally, as applies for any simple sine wave,
411 the following ratios are established:

412 $V_{pp} / V_{rms} = 2\sqrt{2} = 2.828$
 413 $V_{pp} / V_{rms} = 2\sqrt{2} / 2 = \sqrt{2} = 1.414$
 414 Or, inversely:
 415 $V_{rms} / V_{pp} = \sqrt{2} / 4 = 0.354$
 416 $V_{rms} / V_{pp} = 1/\sqrt{2} = \sqrt{2}/2 = 0.707$
 417 ***
 418 unit x05m5d
 419 back x05m5a
 420 next x05m5e
 421 at 205
 422 write The rms value of a periodic voltage is the square
 423 root of the average of the squared voltage.
 424 Calculate V_{rms} for the following wave:
 425 $V_{rms} =$ rms volts (Press -BACK- to review)
 426 at 1235
 427 write $y(t) = 1 \quad 0 < t < T/2$
 428 $= -1 \quad T/2 < t < T$
 429 join x05s5b
 430 gdraw 0, 1; π, 1
 431 gdraw ; π, -1
 432 gdraw ; 2π, -1
 433 gdraw ; 2π, 0
 434 arrow 712
 435 ansy 1.0
 436 no
 437 at 2505
 438 write 1^2 is the same as $(-1)^2$, the average over one
 439 period of the constant 1.0 volt is 1.0 volt, and
 440 the square root of 1. is 1.
 441 ***
 442 unit x05m5e
 443 restart
 444 back x05m5d
 445 next x05m5e1
 446 join imode
 447 jump n47, x05m5e, x
 448 at 505
 449 write Although the VTVM scales are calibrated in the unit
 450 R.M.S. VOLTS, for a simple SINE wave, the VTVM does not
 451 indicate the root-mean-square voltage for any signal.
 452 The actual indication on the VTVM is related to the
 453 input signal by the following formulae:
 454 at 1207
 455 join x05s5a
 456 ***
 457 unit x05m5e1

458 back x05m5e2
459 next x05m5e2
460 at 703
461 write As noted, the VTVM indication for a pure sine wave
462 is its rms voltage, and this is not true generally
463 for every non-sinusoidal waveshape.

464 The relation between the waveshape of a periodic
465 voltage applied at the INPUT of the VTVM, the responsive
466 position of the pointer of the VTVM, and the scale
467 reading indicated by the pointer can be understood
468 more clearly by tracing the effects of the INPUT voltage
469 through a schematic diagram of the VTVM.

----- part=1, block=g -----

block 1g, x05m5e2

471 unit x05m5e2
472 back x05m5e1
473 next x05m5e3
474 join - x05m5e2
475 at 1605
476 write The signal at the INPUT terminals of the VTVM is:

477 $v_{AA} = v(t)$
478 pause
479 mode erase
480 at 1605
481 write The signal at the INPUT terminals of the VTVM is:

482 $v_{AA}' = v(t)$
483 mode write
484 at 1605
485 write $v_{AA}' = v(t)$

486 The capacitor blocks the average value so at BB'
487 only the ripple remains:

488 $v_{BB}' = v(t) - V_{av}$, where $V_{av} = \frac{1}{T} \int_0^T v(t) dt$
489 at 190,456
490 write B
491 at 190,344
492 write B'
493 pause
494 mode erase
495 at 1805
496 write

The capacitor blocks the average value so at BB'
only the ripple remains:

498 $v_{BB}' = v(t) - V_{av}$, where $V_{av} = \frac{1}{T} \int_0^T v(t) dt$
499 mode write
500 at 1805
501 write $v_{BB}' = v(t) - V_{av}$, where $V_{av} = \frac{1}{T} \int_0^T v(t) dt$

502
503 The full-wave rectifier converts all negative values
504 to positive values, so the fully-rectified ripple
at CC' is:

505 $V_{CC'} = |v(t) - V_{av}|$
506 size 7
507 at 352,382
508 write }
509 size 8
510 at 384,400
511 write Full-wave
512 Rectifier
513 at 235,321
514 write C
515 at 333,321
516 write C
517 pause
518 mode erase
519 at 2005
520 write The full-wave rectifier converts all negative values
521 to positive values, so the fully-rectified ripple
522 at CC' is:

523 $V_{CC'} = |v(t) - V_{av}|$
524 mode write
525 at 292,319
526 write M
527 at 2005
528 write $V_{CC'} = |v(t) - V_{av}|$

529 The d'Arsonval mechanism (M), because of its inertia,
530 cannot respond to a frequency greater than 3 Hz, so
531 the pointer responds to the average value of $V_{CC'}$:

532 VTVM response = $1/T \int_0^T |v(t) - V_{av}| dt$

533 pause
534 mode erase
535 at 2205
536 write The d'Arsonval mechanism (M), because of its inertia,
537 cannot respond to a frequency greater than 3 Hz, so
538 the pointer responds to the average value of $V_{CC'}$:

539 VTVM response = $1/T \int_0^T |v(t) - V_{av}| dt$

540 mode write
541 at 2205
542 write VTVM response = $1/T \int_0^T |v(t) - V_{av}| dt$

543 The manufacturer marked this VTVM meter scale to
544 indicate R.M.S. volts when a simple sine wave is
545 applied to the INPUT. Therefore, the VTVM indication is:

546 VTVM indication = $1.11/T \int_0^T |v(t) - V_{av}| dt$

block 1h, x05m5e3

```

548 unit x05m5e3
549 back x05m5e2
550 next x05m5f
551 at 505
552 write
553
554
555
556 at 1207
557 join x05m5a
558 ***

```

In general, the value indicated by the VTVM pointer is 1.11 times the average of the fully-rectified ripple of the INPUT voltage. This is mathematically expressed by the following previously-mentioned formula:

```

559 unit x05m5f
560 back x05m5e
561 next x05m5c
562 calc n120+1
563 erase
564 patchup
565 at 505
566 write
567

```

Let's look at some non-sinusoidal waveforms from the Function Generator and see how this applies.

Accomplish this task:

On the A' channel of the oscilloscope:

Display two cycles of a square wave with $V_{pp} = 20$ V, and $V_{av} = 0$.

Set the A' RREAMP at +DC.

Use a generator frequency of 1 kHz.

Connect the VTVM to measure this same signal, starting with the 300 RANGE and reducing the RANGE until you display the reading most accurately.

577 ***

```

578 unit x05m5g
579 base
580 back x05m5f
581 at 310
582 write What is the reading on the VTVM?

```

```

583 V indicated =
584 at 535
585 writec n120,,,4s,v51
586 goto n120,x,x,x,x05m5g0
587 arrow 533
588 store v51

```

589 ansv 11.0,1
 590 endarrow
 591 entry x05m5g8
 592 at 810
 593 write On the basis of your measurement:
 594 at 1105
 595 write $V_{indicated} = \frac{V_{pp}}{2}$ for a symmetrical square wave.
 596 calc v56e51/20
 597 at 1125
 598 write n120,.,,(s,v56)
 599 goto n120,x,x,x,x05m5g8a
 600 join x05s4f
 601 entry x05m5g1
 602 inhibit erase
 603 back x05m5f
 604 data x05s4f
 605 arrow 1119
 606 ansv v56,10%
 607 no
 608 at 1308
 609 write $V_{pp} = 20$ V.
 610
 611 $V_{indicated} = (s, v51)$
 612
 613 thus, $V_{indicated} = ?? \times V_{pp}$
 614
 615 Press -NEXT- to clear your answer then...
 616 ... press -DATA- to re-use the calculator
 617 endarrow
 618 entry x05m5g8a
 619 calc n120+2
 620 at 1307
 621 write For a square wave symmetrical about 0 V:
 622
$$V_{pp} = 2 V_{dp} = 2 V_{rms}$$

 623 therefore your conversion factor is:
 624
$$V_{rms} = \frac{V_{dp}}{\sqrt{2}}$$
 * the VTVM indication.
 625 at 3204
 626 write -HELP- is available
 627 help x05s5f
 628 join x05s4f
 629 entry x05m5g2
 630 inhibit erase
 631 back x05m5f
 632 data x05s4f
 633 help x05s5f
 634 arrow 2025
 635 ansv .9091,.1
 636 no
 637 at 2210
 638 write Press -NEXT-, to erase your answer,

639 then, press -DATA- to re-use the calculator.
640 endarrow

----- part-1, block-i -----

block ii, x05m5h

642 unit x05m5h
643 back x05m5g
644 next x05m5h1
645 erase
646 catchup

647 at 1010

648 write Now adjust the ± dc level adjust on the function generator to produce a sq. wave such that:

650 $V_{+pk} = 20$ volts and $V_{-pk} = 0$ volts as measured

651 on the scope. The frequency is left at 1 kHz.

652 NOTE: the dc level adjust interacts with the amplitude, therefore, you must adjust them both
653 to obtain the desired signal.

654 at 3007

655 write Press -NEXT- when ready.

657 unit x05m5h1
658 pack x33,+ (ghi) (no) + (cd) (defg) cabac f (tuv) g (ab) >d (defghi) (stu) +++++j
659 join chdu
660 jump n47, x, x05m51
661 next x05m5h
662 ***

663 unit x05m5i

664 back x05m5h

665 next x05m5j

666 at 1010

667 write What is the VTVM indication?

668 _____ volts

670 arrow 1210

671 ansy 11.0, *

672 at 1410

673 write That's correct! Note that changing V_{av}

674 changes V_{rms} as well as V_{g-p} , however,
675 V_{pp} and the indication on the VTVM are
676 the same.

677 ***

678 unit x05m5j

679 back x05m5i

680 at 1010

681 write You could therefore conclude that the

682 VTVM indication for a given waveform
 683 is directly proportional to the
 684 voltage of that waveform. (A,B,C,D)
 685 at 2110
 686 write A)
 687 B) AVERAGE
 688 C) 18-PEAK
 689 D) PEAK-PEAK
 690 arrow 1318
 691 answer (D,c)
 692 . . .

693 unit x05m5k
 694 back x05m5j
 695 at 210
 696 write NOTE: Study this sequence carefully. You'll
 697 be asked a problem based on this method.
 698 at 522
 699 write Consider this waveform:
 700 at 722
 701 size 2
 702 write v(t)
 703 size 0
 704 join x05s5e
 705 gdraw 0,1;2,2;6,0;8,1
 706 pause
 707 at 2818

$$V_{av} = \frac{1}{T} \int_0^T v(t) dt$$

708 write
 709 pause
 710 hbar 0,1,-
 711 at 1148
 712 write $\approx V_{av} = 1$
 713 . . .

714 unit x05m51
 715 back x05m51
 716 at 522
 717 write Performing the operation:
 718
 719 $v(t) - V_{av}$
 720 join x05s5e
 721 gdraw 0,0;2,1;6,-1;8,0
 722 . . .

723 unit x05m5m
 724 back x05m51
 725 at 522
 726 write Next finding the magnitude:
 727
 728 $|v(t) - V_{av}|$
 729 join x05s5e
 730 gdraw 0,0;2,1;4,0;6,1;8,0
 731 pause
 732 at 1818
 733 write calculating: $V_1 = \frac{1}{T} \int_0^T |v(t) - V_{av}| dt$
 734 pause
 735 hbar 0,5,-

736 at 1348
737 write $\downarrow V_1 = .5$
738 pause
739 at 2110
740 write The VTVM should therefore indicate :
741
742 i. $1.11072 \times V_1$ or approximately 1.555 volts

----- part-1, block-j -----

block 1j, "x85m5n

744 unit x85m5n
745 term test
746 back x85m5k
747 at 1010
748 write If you would like to repeat the last graphical
749 sequence explaining the VTVM response.....
750
751 press -BACK-. Otherwise press -NEXT-.
752 ***

753 unit x85m5o
754 back x85m5n
755 erase
756 catchup
757 at 1010
758 write Fit this time you might want to experiment
759 with some waveforms other than the square
760 wave from the function generator. See if
761 you can predict what they should indicate
762 on the VTVM for a given amplitude, then
763 verify this by measuring it with the VTVM.
764
765
766 When you are ready for a challenge to your
767 prowess.....PRESS -NEXT-.

768 at 2110
769 write REMEMBER
770 at 2310
771 join x85s5a
772 ***

773 unit x85m6a
774 calc n12043
775 next x85end
776 back x85m5o
777 base x85s6a
778 help 3210
779 at HELP is available.....
780 write x85s5e
781 join 0.0.5;2,1.5;4,1.5;4,.5;6,-.5;8,-.5;8,.5
782 gdraw 4110
783 at

784 write On the basis of what you have learned in this
785 experiment, what would the VTVM indicate for
786 this waveform? _____ volts
787 at 1916
788 join x05s5a
789 join x05s4f

790 entry x05m6a1
791 inhibit erase
792 data x05s4f
793 help x05s6a
794 next x05end
795 back >x05m5o
796 arrow 625
797 ansv 833..01
798 no
799 at 718
800 write Press -NEXT- to clear your answer then...
801 ...press -DATA- to re-use the calculator
802 ***

803 unit x05s1a
804 at 505
805 write The RANGE setting indicates the largest rms volt
806 signal that the voltmeter can measure. Thus, if
807 you wanted to measure a signal of approximately
808 15 rms volts, you would not set the RANGE dial to
809 10.0, but rather, to 30.0 to obtain a readable
810 indication.
811 end
812 ***

813 unit x05s4a
814 next x05m4a1
815 back x05m4a
816 at 510
817 write I caught you daydreaming, didn't I!
818 at 718
819 write Come on now, you can do better than that
820 I asked for 2000 Hz. In case it slipped your
821 mind....

Freq.out = Freq. setting * Multiplier.

Let's set it carefully and continue on.
Press -NEXT- when ready.

823 unit x05s4b
824 at 510
825 write Surely you're not nervous!
826 Let's try that again.
827 ***

828 unit x05s4b
829 at 510
830 write Surely you're not nervous!
831 Let's try that again.
832
833 Just set the range switch to 30 and then ...
834
835 Press -NEXT-
836 pause

837 pack n33,+++++
838 join ckd
839 jump n47,x05s4b,x05m4c

----- part=1, block=k -----

block 1k, x05s4c

841 unit x05s4c
842 at 510
843 write Not bad. You're just a little high.
844 In order to get good results we need
845 to be a little more precise.

846
847 I want that needle right on .25 VRMS.
848 When you've got it, press -NEXT-.

849 pause
850 jump x05m4d1
851 ***

852 unit x05s4d
853 at 510
854 write You're just a little low. To get good
855 results we must be precise as possible.

856
857 Set the amplitude as close to .25 VRMS
858 as you can and then press - NEXT - .

859 pause
860 jump x05m4d1
861 ***

862 unit x05s4e
863 at 640
864 write Are you sure that you know all that ?

865
866 The A channel should be
867 AC coupled at 100 volts
868 full scale. Internally
869 trigger the sweep from
870 AC levels in the AUTO mode.
871 Display only the A channel,
872 and sweep it normally (not
873 times 5).

874
875 Then, press -NEXT-.

876 pause
877 pack n33,++p++ftab++++++
878 join ckdw
879 jump n47,x,x05m4h
880 next x05s4e
881 ***

882 unit x05s4f
883 inhibit erase

```

884 calcs n120,n121#922,1122,1123,2025,625
885 mode erase
886 at 3019
887 write Press -NEXT- to enter your answer above
888 Press -BACK- to recalculate
889 at n121
890 write >
891 mode write
892 at 2737
893 erase 20
894 at 2838
895 erase 15
896 catchup
897 draw 2617;2657;2957;2917;2617
898 at 2719
899 write CGE Calculator
900 Enter Expression:
901
902 arrow 2837
903 store v100
904 ok
905 endarrow
906 at 2938
907 show v100
908 at 3019
909 write Press -NEXT- to enter your answer above
910 Press -BACK- to recalculate
911 pause
912 goto key=back,x05s4f,x
913 jump n120,x05m4i1,x05m4i2,x05m5g1,x05m5g2,x05m6a1
914 ***

915 unit x05s5a
916 write  $V_{indicated} = \frac{\pi \sqrt{2}}{4} \cdot \frac{1}{T} \int_0^T |v(t) - V_{av}| dt$ 
917
918 where  $V_{av} = \frac{1}{T} \int_0^T v(t) dt$ .
919 Here:  $\frac{\pi \sqrt{2}}{4} = \frac{\sqrt{2}/2}{2/\pi} = 1.11$  for a sine.
920 ***
921 unit x05s5b
922 origin 1510
923 axes 0,-100,300,100
924 scalex 2π
925 scaley 1
926 markx π,π/4
927 labely 1..25

```

----- part=1, block=1 -----

block 11, x05s5b1

```

929 unit x05s5b1
930 at 705
931 write, and calculate the average of the squared wave as Y1:
932 at 2019
933 write  $Y_1 = \frac{1}{T} \int_0^T (v(t))^2 dt.$ 
934 mode rewrite
935 at 1828
936 write Plato is computing Y1 by increments.
937 calc v5940
938 doto 21ine,v70+1,50
939 calc v57+(sin(2πv70/50))2
940 calc v58+(sin(2π(v70-1)/50))2
941 calc v59+v59+(v57+v58)/100
942 calc v71+πv70/25
943 gdraw
944 at
945 showt
946 2line
947 mode erase
948 at 1828
949 write Plato is computing Y1 by increments.
950 mode
951 hbar 2π,.5,-
952 graph 2.1π,.5,Y1
953 end ..
954 ***

955 unit x05s5c
956 pack n33,0000000000000000a00b0+++++b+000ab0
957 join ckow
958 jump n47,x,x05s5d
959 next x05m5f
960 ***

961 unit x05s5d
962 pack n33.+ (ghi) (nop) +(cd) (defg) (bc) aba< f (tuv) g (ab) >d (efghi) (abcd) ++++++j
963 join ckdw
964 jump n47,x,x05m5g
965 next x05m5f
966 ***

967 unit x05s5e
968 origin 1515
969 axes 0,-128,256,128
970 scalex 8
971 scaley 2
972 markx 4,1
973 labely 1,.25
974 at 1730
975 write t/2
976 at 1747
977 write T
978 ***

979 unit x05s5e2
980 at 177
981 write HP 4000D VACUUM TUBE VOLTMETER

```

982 draw 117;146
983 at 1413
984 write Internal Schematic Diagram of the VTVM
985 draw 1413;1451
986 at 70,431
987 write +
988 v(t)
989
990 draw 88,448;138,448;skip;138,453;138,443
991 circle 7,150,448,135,225
992 draw 143,448;193,448;193,428;197,424;189,416;197,408
993 189,400;197,392;193,388;193,368;88,368;skip;193,448;293,448;skip;193,368;293,368
994 draw 293,448;276,431;skip;271;426;254,409;271,392
995 skip;276,387;295,368;314,387;skip;319,392
996 336,409;319,426;skip;314,431;297,448
997 draw 276,431;276,424;269,431;276,431;skip;280,427
998 272,435
999 draw 276,387;276,394;269,387;276,387;skip;280,391
1000 272,383
1001 draw 319,391;319,384;312,391;319,391;skip;315,395
1002 323,387;skip;319,426;319,433;312,426;319,426
1003 skip;323,430;315,422
1004 draw 254,409;254,374
1005 circle 6,254,368,90,270
1006 draw 254,361;254,329;280,329
1007 circle 15,295,329
1008 draw 309,329;336,329;336,409
1009 at 85,456
1010 write A
1011
1012 at 85,360
1013 write
1014 at A
1015 at 190,440
1016 write
1017 at 190,360
1018 write
1019 at 292,440
1020 write
1021 at 251,401
1022 write
1023 at 333,401
1024 write
1025 at 292,360
1026 write
1027 at 251,321
1028 write
1029 at 333,321
1030 write
1031 end

part=1, block=m

block 1m, x05s5f

1033 unit x05s5f
1034 erase
1035 catchup
1036 at 811
1037 write $V_{pp} = 2 V_{gp} = 2 V_{rms}$

1038 $V_{indicated} = \langle s, v51 \rangle \times V_{pp}$
1039 $\times 2$

1040 $V_{pp} = \frac{2\pi}{\langle s, v51 \rangle} \times V_{indicated}$

1041 thus, $V_{rms} = \frac{V_{pp}}{\sqrt{2}} = \frac{2\pi}{\langle s, v51 \rangle \times 2} \times V_{indicated}$

1042 pause
1043 jump x05m5g
1044 ***
1045
1046 ***

1047 unit x05s6a
1048 back x05m6a
1049 erase
1050 catchup
1051 join x05s5e
1052 gdraw 0,0.5;2,1.5;4,1.5;4,0.5;6,-0.5;8,-0.5;8,0.5
1053 hbar 0.25,.5,
1054 at 525
1055 write $V_{av} = \int_0^T v(t) dt$
1056 locate 8.5,.4
1057 write $\leftarrow V_{av} = 172$
1058 ***

1059 unit x05s6b
1060 back x05s6a
1061 at 525
1062 write Performing the operation:
1063 $v(t) - V_{av}$
1064 join x05s5e
1065 gdraw 0,0;2,1;4,1;4,0;6,1;8,-1;8,0
1066 ***

1067 unit x05s6c
1068 back x05s6b
1069 at 522
1070 write Next, finding the magnitude
1071 $| v(t) - V_{av} |$
1072 join x05s5e
1073 gdraw 0,0;2,1;4,1;4,0;6,1;8,1;8,0
1074 ***

1075 unit x05s6d
1076 back x05s6c
1077 help x05s6e
1078 next x05m6a
1079 join x05s5e

1080 gdraw $g, \theta; 2, 1; 4, 1; 4, 0; 6, 1; 8, 1; 8, 0$
 1081 at 321
 1082 write Recalling the formula:
 1083 $V_{\text{indicated}} = \frac{\pi\sqrt{2}}{4} \cdot \frac{1}{T} \int_0^T |v(t) - V_{\text{av}}| dt$
 where $\frac{\pi\sqrt{2}}{4} = 1.11$,
 1084 at 2085
 1085 write Note that the area to the left of $t=T/2$ is identical
 1086 to the area to the right.
 1087
 1088 Thus, you only need to integrate from $t = 0$ to
 1089 $t = T/2$ and multiply by two.
 1090 Press -NEXT- to enter your answer.
 1091 Press -HELP- for further assistance.
 1092 ***
 1093 unit x05s6e
 1094 back x05s6d
 1095 next x05s6f
 1096 help x05s6g
 1097 at 709
 1098 write To find the area under the curve $|v(t) - V_{\text{av}}|$:
 1099 Press -NEXT- for a geometric approach.
 1100 Press -HELP- to solve the integral directly.
 1101 ***
 1102 unit x05s6f
 1103 help x05s6g
 1104 back x05s6a
 1105 next x05m6a
 1106 join x05s5e
 1107 gdraw $g, \theta; 2, 1; 4, 1; 4, 0; 6, 1; 8, 1; 8, 0$
 1108 at 208
 1109 write Note that the figure to the left of $t=T/2$ is:
 1110 (rectangle of area $1/2$)
 1111 doto 3line, p101+1, 8, 1
 1112 calc v102+en101 * 0.25
 1113 calc v103+en101 * 0.125
 1114 hbar v102, v103, -
 1115 3line
 1116 at 432
 1117 write - (shaded triangle $\frac{1}{2} \times \frac{1}{4} \times 1$)
 1118 at 622
 1119 write $= \frac{1}{2} - \frac{1}{8} = \frac{3}{8}$
 1120 at 1924
 1121 write Recall that the total area is twice
 1122 as large ($= 2 \times 3/8 = 3/4$)
 1123 and $V_{\text{indicated}} = 1.11072 \times 3/4$
 1124 write (at, 2608) Press -NEXT- to enter your answer

1125

-BACK- to review this sequence

1126

-HELP- to see the integral approach

-----part=1, block=n-----

block in, x05end

```
1128 .unit. x05s6g
1129 help x05s6f
1130 batch x05s6a
1131 next x05m6a
1132 join x05s5e
1133 gdraw 0,0;2,1;4,1;4,0;6,1;8,1;6,0
1134 at 321
1135 write  $V_{indicated} = \frac{\pi\sqrt{2}}{4} \cdot \frac{1}{T} \int_0^T [v(t) + V_{av}] dt$ 
1136 pause
1137 at 621
1138 write  $= 1.11072 \times \frac{1}{T} \times 2 \times \left[ \frac{T}{4} \cdot \frac{4}{T} \cdot t dt + \frac{T}{2} \right] dt$ 
1139 at 541
1140 write [
1141 pause ]
1142 pause
1143 at 921
1144 write  $= 1.11072 \times \frac{1}{T} \times 2 \times \left[ \frac{4}{T} \cdot \frac{t^2}{2} \Big|_0^T + \left( \frac{T}{2} - \frac{T}{4} \right) \right]$ 
1145 at 841
1146 write [
1147 pause ]
1148 pause
1149 at 2021
1150 write  $= 1.11072 \times \left[ 2 \times \left[ \frac{4}{T} \cdot \frac{t^2}{2} \Big|_0^T + \left( \frac{T}{2} - \frac{T}{4} \right) \right] \right]$ 
1151 calc v61=-.1
1152 zero v62,
1153 mode rewrite
1154 at 1821
1155 write Plato Computing Integral
1156 doto iline,v60#0,20
1157 calcs v60-11,v61+v61+0.1,1
1158 gdraw 0.2*x*v60,0;0.2*x*v60,v61
1159 gdraw (0.2*x*v60)+4,0;(0.2*x*v60)+4,v61
1160 calc v60-11,v63#0.0125*x*v60*x*v61,v62+v63+(0.025*x*v60*x*v61)-0.25
1161 at 2038
1162 write v60-11,(t,v63),(t,v62)
1163 iline
1164 at 1821
1165 write
1166 mode write
1167 at 2608
1168 write Press. -NEXT- to enter your answer
```

1169

-BACK- to review this sequence

1170

-HELP- for the geometrical approach.

1171 ***

```

1172 unit : x05end
1173 back : x05m6a
1174 join mode
1175 jump n47,x05end,x
1176 course n2
1177 calc n2='ee244',
1178 nc(n21+1) <(nc(n21+1)$mask$07777777770000000000)+046030000000,
1179 nc(n21+1) &nc(m21+1)
1180 erase
1181 output /// student has completed experiment ///
1182 join endunit
1183 join jmpmes
1184 jumpout cgeindex,quest

1185 entry leave
1186 end lesson
1187 ***

1188 unit endunit
1189 course n2
1190 jump n2='ee244',leave,x
1191 calc nc(n21+7)&nc(n21+7)+ahelp
1192 vc(n21+6)&vc(n21+6)+atime/60000
1193 ***Incl.cge s.r. & terms sample,index,comment,slides.
1194 use eex00,ck1
1195 use ck2
1196 use ck3
1197 use ck4
1198 use ck5
1199 use ck6

ckaw not found 226 387 957
ckd not found 281 212 240 296 838
ckdw not found 77 659 878 963
ckd1 not found 243 246
endunit x05end 1188 22 1182
imode not found 34 184 446 1174
jmpmes not found 1183
leave x05end 1185 1190
x05end x05end 1172 775 794 1175
x05m0a eex05id 30 35 52
x05m1a x05m1a 51 33 66
x05m1b x05m1a 65 53 79 82
x05m1b1 x05m1a 74 67
x05m2a x05m1a 81 78 96
x05m2b x05m1a 95 83 118
x05m2c x05m1a 117 97 125
x05m2d x05m2d 124 119 153
x05m3a x05m2d 152 126 198
x05m4a x05m2d 181 154 185 210 815
x05m4a1 x05m2d 199 814
x05m4b x05m2d 204 202 224
x05m4c x05m4c 215 213 228 231 839
x05m4d x05m4c 230 227 258
x05m4d1 x05m4c 238 232 255 850 860
x05m4e x05m4c 257 241 268 313 330 351
x05m4f x05m4c 267 259 287

```

x05m4g	x05m4c	286	269		
x05m4h	x05m4h	299	297	309	879
x05m4i	x05m4h	311	308	368	
x05m4i1	x05m4h	327	913		
x05m4i2	x05m4h	348	913		
x05m5a	x05m4h	366	314	383	419
x05m5b	x05m4h	382	369	407	
x05m5c	x05m5c	406	384		
x05m5d	x05m5c	418	408	444	
x05m5e	x05m5c	442	420	447	458
x05m5e1	x05m5c	457	445	472	568
x05m5e2	x05m5e2	471	459	549	
x05m5e3	x05m5e3	548	473		
x05m5f	x05m5e3	559	550	580	603
x05m5g	x05m5e3	578	643	964	1045
x05m5g0	x05m5e3	591	586		
x05m5g0a	x05m5e3	618	599		
x05m5g1	x05m5e3	601	913		
x05m5g2	x05m5e3	629	913		
x05m5h	x05m5h	642	661	664	
x05m5h1	x05m5h	657	644		
x05m5i	x05m5h	663	660	679	
x05m5j	x05m5h	678	665	694	
x05m5k	x05m5h	693	715	746	
x05m5l	x05m5h	714	724		
x05m5m	x05m5h	723			
x05m5n	x05m5n	744	754		
x05m5o	x05m5n	753	776	795	
x05m6a	x05m5n	773	1048	1078	1105
x05m6a1	x05m5n	790	913		1131
x05s1a	x05m5n	803	68	75	127
x05s4a	x05m5n	813	202		
x05s4b	x05m5n	828	213	839	
x05s4c	x05s4c	841	244		
x05s4d	x05s4c	852	247		
x05s4e	x05s4c	862	297	880	
x05s4f	x05s4c	882	326	329	347
			632	789	604
x05s5a	x05s4c	915	455	557	350
x05s5b	x05s4c	921	378	388	629
x05s5b1	x05s5b1	929	392		
x05s5c	x05s5b1	955	561		
x05s5d	x05s5b1	961	958		
x05s5e	x05s5b1	967	704	728	729
			1079	1106	1064
x05s5e2	x05s5b1	979	474		781
x05s5f	x05s5f	1033	627	633	1072
x05s6a	x05s5f	1047	778	793	1051
x05s6b	x05s5f	1059	1068		
x05s6c	x05s5f	1062	1076		
x05s6d	x05s5f	1075	1094		
x05s6e	x05s5f	1093	1077		
x05s6f	x05s5f	1102	1095	1129	
x05s6g	x05end	1128	1096	1103	
ahelp		1191			
atime		1192			
back		198	210	224	912

key	198	218	224	912			
nc	1178	1178	1179	1179	1191	1191	
n181	1111	1112	1113				
n120	315	344	562	585	586	619	598 774 599
	004	913					
n121	004	889					
n2	1176	1177	1189	1190			
n21	1178	1178	1179	1179	1191	1191	1192 1192
n33	76	208	211	225	209	295	242 306 245
	658	037	877	956	962		
n47	35	76	185	182	213	244	227 247 241
	297	308	447	668	039	964	079 1175 958
sin	388	398	939	948			
sqrt	394						
vc	1192	1192					
v100	903	907					
v102	1112	1114					
v103	1113	1114					
v51	585	588	596	611	1038	1041	1043
v55	319	322	337	353	368	388	394 398
v56	322	332	596	598	606		
v57	939	941	943				
v58	940	941					
v59	394	937	941	941	945		
v60	394	396	1156	1157	1158	1159	1158 1160 1160 1159
	1160	1160	1162				
v61	1151	1157	1157	1158	1159	1160	1160
v62	1152	1160	1162				
v63	1160	1160	1162				
v70	938	940					
v71	942	943	943				
%	332	353	606				
Vrms	398						
Y ₁	952						
	397	710	735	951	1053	1114	
	397	398	430	431	432	926	926 924
WV78	940	951	952				
	939	942					

* lesson information

lesson name = eex05

starting date = 06/01/73

last edited on 08/21/74 at 11.23.41

by neal of course eecge

at site 2, station 27

author name = J. P. Neal

department = EE

telephone number = 333-4351

discipline = EE

grade level = Freshman

description of lesson = The Operation and Uses of the Vacuum Tube Voltmeter, HP 488D.

----- part=1, block=a -----

block 1a, eex06id

2 stop
 3 *** For Neal, CGERL, Room 248, EEB.

4 One line description of this lesson

5 Measurements of Transients.

6 Divisions of this Lesson:

Block Unit

7	Id for this file	eex06id
8	Experiment eex06;	
9	Objectives	x06m0a
10	Measure transient waveshapes	x06m0a
11	Measure and calc. time const.	x06m1q0

12 Final edit 21 aug 74 neal.

13 *list info
 14 *list symbols
 15 *list varian,charset,cgeindex,cgechar
 16 ***
 17 start
 18 finish endunit
 19 write 1(at,1010) Loading the CGE Character Set
 20 charset cgeindex,cgechar
 21 erase
 22 dataon
 23 area eex06
 24 ext 0
 25 calc n99+1 \$\$ used for restart skipping

----- part=1, block=b -----

block 1b, x06m0a

27 unit x06m0a
 28 restart
 29 join imode
 30 jump n47,x06m0a,x
 31 next x06m0b
 32 calc n99+0
 33 at 407
 34 write

MEASUREMENTS OF TRANSIENTS

35 This is an experimental study of transients in a

36 series circuit which contains resistors and a single
37 energy-storage element, such as a capacitor or an
38 inductor.

39 The principal objectives of this experiment are:

40 1. To measure and compare the waveshapes of the input
41 and element voltages, currents, powers, and energies
42 in a series RC circuit, when the source voltage is
43 constant.

44 2. To measure the time constant of the current of a
45 series RC circuit and compare it with the value
46 calculated from the nominal parameters of the circuit
47 devices.
48 ***

49 unit x06m0b
50 back x06m0a
51 next x06m1a
52 at 707

53 write A square-wave voltage is constant during each
54 half-period. Consequently, when a square-wave
55 voltage drives a series RC or RL circuit, the
56 circuit's response to a constant voltage can be
57 studied by examining its response to the square-
58 wave voltage during any half-period. Furthermore,
59 being repetitive, the input and element voltages
60 can be displayed on the Scope.

61 pause
62 at 1987
63 write Hence, the response of an RC circuit to a constant
64 voltage applied when the capacitor is INITIALLY
65 DISCHARGED can be studied experimentally by driving
66 the RC circuit with a square-wave voltage having a
67 zero value during each alternate half-period, and
68 a frequency sufficiently low for the transients to
69 decay practically to zero during each half-period.
70 ***

71 unit x06m1a
72 back x06m0b
73 next x06m1a
74 help x06s1a
75 at 707

76 write Display one period of the adjustable SQUARE OUTPUT
77 of the Function Generator on channel A of the Scope.

78 Trigger the Scope from the Function Generator.

79 Accurately adjust the open-circuit SQUARE-wave
80 OUTPUT of the Function Generator to:

81 $V_{max} = 20 \text{ V}, V_{min} = 0, \text{ and } f = 1000 \text{ Hz.}$

82 Use A VOLTS FULL SCALE at 20 V for greatest accuracy,
83 and lower the zero volts base line of the display

84 to the bottom line, 5 cm below the center of the
85 CRT screen.

06 Disregard any small peak at the start of the trace.

Recall that the possible error with the Scope is $\pm 3\%$ of the VOLTS FULL SCALE setting, so you should avoid introducing further errors due to inaccuracies in your settings, readings, or calculations.

part=1, block=c

block 1c, x06mia1

```
92 unit    x@6mia1
93 pack    n33,00000000000000000000000000000000
94 join    ckw
95 next    n47,x@6mia1,x
96 jump    n47,x,x@6mia2
97 ***
```

```
98 unit x@6m1a2  
99 pack n33,+gne(cd)(de)caba< f(rstuv)g(ab)>d(xet)(tu)+aaa++1  
100 join ckdw  
101 next n47,x@6m1a,x  
102 jump n47,x,x@6m1b  
103 kxx
```

104 unit x06m1b
105 at . 1007

106 write The Scope is the most accurate of the rack-
107 mounted instruments. Consequently, please readjust
108 the frequency of the Function Generator, so the
109 swept length of one period, as observed on the Scope,
110 is exactly 10 cm, for the period of 1 ms and the
111 frequency of 1000 Hz.

```
113 unit    x@6m1@1
114 pack    n33, @00000000000000000000000000000000
115 join    ckow
116 next    n47, x@6m1a, x
117 jump    n47, x, x@6m1b2
118 ***
```

```
119 unit . x06m1b2
120 pack n33,+gne(cd),(de)caba< f(stu)g(ab)>d(ef),(tu)+aaa+e
121 join ckdw
122 next . n47,x06m1a,x
123 jump . n47,x,x06mic
124 ***
```

125 unit x06mic
126 back x06mia

127 next x06mid
128 jump n99,x,x,x06m1i1,x06m1q8a \$ units added for retarts
129 at 807
130 write DO NOT readjust any dial or knob on the Function
131 Generator during the remainder of this task. You
132 have correctly set the open-circuit voltage v_g of the
133 Function Generator and it will automatically try
134 to maintain the terminal voltage constant.

135 However, the terminal voltage will still vary with the
136 load current, as was observed in a previous experiment
137 where it was found that the Function Generator with
138 the controls at a fixed setting could be approximately
139 represented theoretically by an ideal voltage source
140 v_g in series with an internal resistance R_g .
141 ***

142 unit x06mid
143 back x06mic
144 next x06mid1
145 help x06sia
146 at 707
147 write, Connect the sensor cable of the RC BOARD, ITEM 33,
148 to the CGE Interface.

149 Ground Terminal 4 of the RC BOARD.

150 Drive Terminal 1 of the series resistor-capacitor
151 circuit with the adjusted SQUARE-wave OUTPUT of the
152 Function Generator. Note how the display of v_{in} changes!

153 Observe the input voltage v_{in} on channel A with
154 A VOLTS FULL SCALE at 50 V, and observe the input
155 current i on channel B with B VOLTS FULL SCALE at
156 2 V. Return the zero base line to the center of
157 the screen.

158 -HELP- is available.
159 ***

160 unit x06mid1
161 pack n33,abbc0000000000cdabdd0000ad0000c000
162 join ckw
163 next n47,x06mid,x
164 jump n47,x,x06mid2
165 ***

166 unit x06mid2
167 pack n33,kgoc (cd) (de) cdba<f (stu) g (ab) >d (ef) (tu) +aaa++1
168 join ckdw
169 next n47,x06mid,x
170 jump n47,x,x06m1e

----- part=1, block=d -----

block id: x06m1e

```
172 unit x06m1e
173 base
174 back x06m1d
175 next x06m1f
176 define x06n120
177 y06n121
178 xmax06n122
179 ymax06n123
180 calc x#398
181 y#425
182 xmax#20
183 xmax#10
184 join x06s1b
185 gdraw -10,0;-10,16;0,16,0,0;10,0
186 graph 2,20,vg(t)
187 at 66
188 write t
189 at 405
190 write The voltage source of the
191 RC circuit is a square wave
192 having:
```

```
193 Vmax = volt.
194 Vmin = volt.
195 arrow 818
196 long 2
197 answer 20
198 no
199 at 1205
200 write If you have not change the Function Generator
201 controls, Vmax of vg should be 20 volt.. The Scope
202 is displaying the input voltage of the RC circuit.
```

The source voltage is theoretically internal to
Function Generator and cannot be displayed under load.

```
203
204
205 arrow 1018
206 answer 0
207 long 1
208 inhibit erase
209 no
210 at 1205
211 write If you have not changed the generator controls,
212 Vmin of vg should be 0 volt.
213 endarrow
214 ***
```

```
215 unit x06m1f
216 back x06m1e
217 next x06m1g
218 calc y#255
219 join x06s1b
```

```
228 calc n95+1  
221 doto 06m1f1,n94+10,5,10  
222 gdraw n94,0;n94,n95(20)  
223 graph 2,0,i(t)  
224 at 1561  
225 write t  
226 funct n95(20)exp(-.5(v100-n94)),v100+n94,n94+10,-5  
227 calc n95+n95*-1  
228 06m1f1  
229 at 1305
```

Without changing any connections, turn the A PRE AMP to OFF and by adjusting the A*B SEPARATION knob, use the undeflected channel A trace for a zero baseline of the current display.

```
237 pause  
238 mode erase  
239 at 1305  
240 write Without changing any connections, turn the A PRE AMP to OFF and by adjusting the A*B SEPARATION knob, use the undeflected channel A trace for a zero baseline of the current display.
```

```
241 inhibit erase  
242 jump x06m1f1  
243 ***
```

```
250 unit x06m1f1  
251 pack n33,a0bc00000000c0ab0000ad0000c0  
252 join ckd  
253 inhibit erase  
254 jump n47,x06s1c,x06m1f2  
255 ***
```

```
256 unit x06m1f2  
257 pack n33,kgdc(cc)(de)edba< f(rstu)g(ab)>d(ef)(tu)7aaa++1  
258 join ckd  
259 inhibit erase  
260 jump n47,x06s1c,x06m1g
```

----- part=1, block=e -----

block ie, x06m1g

```
262 unit x06m1g  
263 back x06m1e  
264 next x06m1h  
265 at 1305  
266 write The exponential current  
267 of the RC circuit, read
```

268

experimentally has:

269

$$I_{\max} = / \text{ mA}$$

270

$$I_{\min} = / \text{ mA}$$

271

arrow 1718

272

ansv 8.4.1

273

no

274

at 2205

275

write You can read the amplitude
more accurately by momentarily
going to a smaller FULL SCALE
setting on B VOLTS.

276

arrow 1918

277

ansv -8.0,1

278

inhibit erase

279

no

280

at 2205

281

write You can read the amplitude
more accurately by momentarily
going to a smaller FULL SCALE
setting on B VOLTS.

282

endarrow

283

inhibit erase

284

291

unit x06m1h

292

back x06m1te

293

next x06m1h1

294

calc y485

295

y_{max} #200

296

join x06s1b

297

graph 2,200,p_g(t)

298

graph 10,-20,t

299

doto 06m1h1,n94+-10,-2,10

300

gdraw n94,0;n94,20(8.8)

301

funct 20(8.8) exp(-1.(v100-n94)),v100+n94,n94+10,.5

302

06m1h1

303

at 2505

304

write The power delivered by the
source can be calculated
by simply multiplying the
source voltage (20 or 0 V) by
the current for each point in
time.

311

unit x06m1h1

312

next x06m1h1

313

at 1007

314

write Now, in order to read i(t) versus t more accurately
for the next tabulation, please set the Scope TIME
at 500 μ s and B VOLTS at 1 V.
Turn the A PRE-AMP to +DC.

315

pause

316

pack n33,abcb00000000c00ab0000ad000000

317

join ckow

318

319

join

320

321 jump n47,x,x06m1h2
322 ***

323 unit x06m1h2
324 next x06m1h1
325 pack n33,j fcc(cd)'(de)-(cd) dba< f(rtu)/g(ab)>d(eF)(tu)+aaa++1
326 join ckdw
327 jump n47,x,x06m1

part=1, block=f

block 1f, x06m1i

329 unit x06m1i

330 base

331 help x06s1f

332 back x06m1e

333 at 207

334 write Enter the values of the source voltage v_g , and
335 measure on the Scope display and enter the values of
336 of the circuit current i , in the table below. As you
337 properly enter each pair of values, I will then
338 calculate and enter $p_g = v_g \cdot i$ within 6 %.

	t (ms)	v_g (V)	i (mA)	p_g (mW)
340	0.02			
341	0.1+			
342	0.2+			
343	0.3+			
344	0.4+			
345	0.5+			
346	0.6+			
347	0.7+			
348	0.8+			
349	0.9+			
350				

Help is available

351
352 goto key=back,replot;x
353 calc n100#1224
354 n1#104
355 v101#20
356 v102#8.4

```

357 join x06s1d
358 calc v102<3.3
359 join x06s1d
360 calc v102<1.2
361 jjoin x06s1d
362 calc v102<.5
363 join x06s1d
364 calc v102<.2
365 join x06s1d
366 calc v102<-7.6
367
368 join x06s1d
369 calc v102<-3.6
370 join x06s1d
371 calc v102<-1.2
372 join x06s1d
373 calc v102<-.5
374 join x06s1d
375 calc v102<-.2
376 join x06s1d
377 pause

378 entry replot
379 next x06m1i0
380 jump key=back,x,x06m1i0
381 at 1223
382 write 20      {s,v80} {s,v105}
383          20      {s,v81} {s,v106}
384          20      {s,v82} {s,v107}
385          20      {s,v83} {s,v108}
386          20      {s,v84} {s,v109}
387          0       {s,v85} 0
388          0       {s,v86} 0
389          0       {s,v87} 0
390          0       {s,v88} 0
391          0       {s,v89} 0
392 ***

393 unit x06m1i0    $$ this is a dummy unit for restart
394 restart
395 jump n99,x,x,x06mia

396 entry x06m1i1
397 zero n99
398 jump x06m1j
399 ***
400 unit x06m1j

```

```

401 back x06m1i
402 next x06m1k
403 at 807
404 write The input power  $p_g$ , calculated above,
405 will be plotted versus time  $t$ , when you press -NEXT-.
406 calc  $y_{max} \leftarrow 200$ 
407  $x_{max} \leftarrow 10$ 
408  $x \leftarrow 248$ 
409  $y \leftarrow 160$ 
410 pause
411 entry power
412 join x06s1b
413 gdraw -10,0;-10,v105;-8,v106;-6,v107;-4,v108;-2,v109;0,0
414 graph 2,200, $p_g(t)$ 
415 graph 10,-20; $t$ 
416 exit
417 calc  $n149 \leftarrow 104$ 
418 doto 06m1j1,n150+1,5,1
419 graph -12+2(n150), $v(n149+n150)$ ,*
420 06m1j1
421 doto 06m1j2,n150+1,6,1
422 graph 2(n150-1),0,*
423 06m1j2

```

part=1, block=g

block ig, x06m1k

```

425 unit x06m1k
426 base
427 term work
428 back x06m1i
429 next x06m1l
430 at 405
431 write The energy  $w_g(t)$  supplied to the circuit by the
432 voltage source  $v_g$  is
433  $w_g(t) = \int_0^t p_g(t) dt.$ 

```

When you press -DATA-, I will calculate and
plot $w_g(t)$ versus t for one period, using your data.

```

436 calc  $y_{max} \leftarrow 50$ 
437  $x \leftarrow 248$ 
438  $y \leftarrow 160$ 
439  $x_{max} \leftarrow 10$ 
440 pause
441 entry work
442 join x06s1b
443 graph 2,50, $w_g(t)$ 
444 graph 10,-5; $t$ 

```

```

445 calc : n111+104
446 . v112+v134+0
447 . n130+1
448 . n132+10

449 entry x06m1k1
450 calc v131+(v(n111+n130)-v(n111+n130+1))/4
451 doto 06m1k2,v140+.25,1,.25
452 calc v133+v(n111+n130+1)+(1-v140+.25)*4(v131)
453 calc v112+v112+.025*133
454 gdraw 2(v140-.25)+n132,v134;2(v140)+n132,v112
455 calc v134+v112
456 06m1k2
457 calc n130+n130+1
458 . n132+n132+2
459 goto n132-2,x06m1k1,x
460 gdraw 0,v112;10,v112
461 exit
462 at 2912
463 write wg(t) = ∫0T Pg(t) dt. = (z, v112) μJ (within 9%)
464 ***

```

```

465 unit x06m1l
466 base
467 term resis
468 back x06m1k
469 next x06m1m
470 at 305
471 write While the energy was being supplied to the RC
circuit by the source, energy was being dissipated in
the resistances of the circuit. The total resistance
of the RC circuit includes the generator internal
resistance well as the resistances of the various
circuit elements on the RC BOARD. Hence, in the
equivalent circuit below:

```

$$R = R_g + R_1 + R_2$$

```

478 draw 2023;2030;1931;2133;1935;2036;2044;2344;skip
479 . 2341;2047;skip;344,136;2044;2744;2723;2523
480 circle 36,343,101,132,48
481 draw 2523;176,122
482 draw 176,149;2023
483 circle 14,176,136
484 at 1933
485 draw R
486 write R
487 at 2449
488 write C
489 at 2229
490 write i
491 draw 235,164;271,164
492 at 2318
493 write +
494 vg
495 -
496 pause
497 at 1305

```

498 write As you may verify, the manufacturer's rated
499 equivalent resistance values for the Function
500 Generator and the circuit board resistors give
501 $R = 200 + 2000 + 100 = 2300$ ohms.

----- part-1, blockh -----

block 1h, x05min.

503 unit x06min
504 back x06mil
505 next x06min
506 at 507

507 write Let's check this with your experimental
508 measurements.

509 As we mentioned previously, the
510 capacitor voltage is zero when v_g jumps from 0 to
511 20 Volts at the beginning of each period. Therefore,
512 at that instant the only opposition to the flow of
513 current is the resistance voltage $v_R = iR$. Using
514 this relation and your previously-measured current
515 in milliamperes:

516 $R = 20 / (0.001 \times (s, v80)) = (s, 20 / (v80 \times .001))$ ohms (within 6%)
517 When you press -NEXT-, I will use your value of R
518 with the values you read for i to calculate and
519 display the power dissipation $p_R = i^2 R$ versus t.

520 pause
521 erase
522 at 210
523 write An estimate of the power being dissipated at any
524 instant t in the circuit resistance R is

$$p_R(t) = i^2(t) R$$

525 calc y#350
526 x#248
527 y_{max}#200
528 x_{max}#10

529
530 entry resisp
531 join x06s1b
532 graph 1.5, 200, p_R(t)
533 graph 10, -20, t
534 calc v1#20/v80
535 gdraw -10, 0; -10, v1(v80)²; -8, v1(v81)²; -6, v1(v82)²; -4, v1(v83)²; -2, v1(v84)²; 0, 0
536 gdraw 0, 0; 0, v1(v85)²; 2, v1(v86)²; 4, v1(v87)²; 6, v1(v88)²; 8, v1(v89)²; 10, 0
537 exit
538 pause
539 at 1610

540 write An estimate of the energy $w_R(t)$ dissipated in R
541 during the interval $t = 0$ to $t = t$ is

$$w_R(t) = \int_0^t p_R(t) dt.$$

```

543 calc y+115
544      ymax*58
545 entry review
546 join x86m1b
547 graph 1.5,58,wr(t)
548 graph 18,-5,t
549 calc n111+79
550      v112+v134+8
551      n138+1
552      n132+18.

553 entry x86m1m1
554 calc v131+(v(n111+n138)-v(n111+n138+1))/4
555 doto 86m1m2,v148+.25,1,.25
556 calc v133+v(n111+n138+1)+(1-v148+.25)*4(v131)
557 calc v112+v112+.025(v133)2v1
558 gdraw 2(v148-.25)+n132,v134;2(v148)+n132,v112
559 calc v134+v112
560 86m1m2
561 calc n138+n138+1
562      n132+n132+2
563 goto n132<=4,x86m1m1,x
564 gdraw -2,v112;8,v112
565 calc n111+84
566      n138+1
567      n132+0

568 entry x86m1m3
569 calc v131+(v(n111+n138)-v(n111+n138+1))/4
570 doto 86m1m4,v148+.25,1,.25
571 calc v133+v(n111+n138+1)+(1-v148+.25)*4(v131)
572 calc v112+v112+.025(v133)22.353
573 gdraw 2(v148-.25)+n132,v134;2(v148)+n132,v112
574 calc v134+v112
575 86m1m4
576 calc n138+n138+1
577      n132+n132+2
578 goto n132<=6,x86m1m3,x
579 gdraw 8,v112;10,v112
580 exit
581 at 3112
582 write wr(t) = ∫0T pr(t) dt. =(z,v112). μJ

```

----- part-1, block-1 -----

block 1i, x86min

```

584 unit x86min
585 base
586 back x86m1m
587 next x86m1m1
588 at 705
589 write Let's examine the voltage across the capacitor

```

598 in the experimental RC circuit, and relate it to the
599 current i.

592 For this purpose, please return the Scope TIME to
593 1 ms, B VOLTS to 2 V, and A VOLTS to 50 V, and
594 raise the base line to the center of the screen.

595 Since v_{34} across the current-sensing resistor is
596 insignificant in comparison, v_{24} is like v_C .

597 Therefore, monitor Terminal 2 on the A channel to
598 display $v_C(t)$.
599 ***

600 unit x06min1
601 next x06min
602 pack n33,aebc0000000000c00ebd0000ad000c00
603 do ckdw
604 jump n47,x,x06min2
605 ***

606 unit x06min2
607 next x06min
608 pack n33,kgoc(cd)(de)(cd)dba< f(rt)g(ab)ad(cd)(tu)+aaan+1
609 do ckdw
610 jump n47,x,x06min0
611 ***

612 unit x06m10
613 back x06min
614 next x06m1p
615 jump n99;x,x,x,x06m1q8
616 calc x#356
617 y#425
618 xmax#20
619 xmax#10
620 join x06s1b
621 graph 8,20,v_C(t)
622 graph 10,-2,t
623 calc n95#1
624 doto 1lasta,n94#-10,5,10
625 funct n95(20-20exp(-.5(v100-n94))+(n95-1)²(20exp(-.5(v100-n94))),v100+n94,n94+10,.5
626 calc n95=1,n95#0,n95#1
627 1lasta
628 at 505
629 write The voltage v_C across the
630 capacitor is exponentially
631 increasing towards 20 when
632 $v_g = 20$, and is exponentially
633 decreasing towards 0 when $v_g = 0$.
634 ***

635 unit x06m1p
636 back x06m10
637 term try:
638 next x06m1q8
639 at 105..

648 write For this analysis, please read from the Scope and
641 properly enter each value of $v_C(t)$, I will then
642 calculate and enter $p_C = v_C \cdot i$.

	t (ms)	v_C (V)	i (mA)	p_C (mW)
643				
644	0.0-			
645	0.1-			
646	0.2-			
647	0.3-			
648	0.4-			
649	0.5-			
650	0.6-			
651	0.7-			
652	0.8-			
653	0.9-			
654	goto key=back,replotv,x			
655	calc n100+922			
656	n1+80			
657	v102+0			
658	join x06s1e			
659	calc v102+12			
660	join x06s1e			
661	calc v102+16			
662	join x06s1e			
663	calc v102+18			
664	join x06s1e			
665	calc v102+19			
666	join x06s1e			
667	calc v102+20			
668	join x06s1e			
669	calc v102+8			
670	join x06s1e			
671	calc v102+3			
672	join x06s1e			
673	calc v102+1.8			
674	join x06s1e			
675	calc v102+4.4			
676	join x06s1e			
677	pause			
678	entry replotv			
679	next x06m1q0			
680	jump key=back,x,x06m1q0			
681	calc n100+922			
682	n1+80			
683				

```
684. doto iplot,n150#0,9,1  
685 at n100+2  
686 show v(n1+n150-30)  
687 at n100+10  
688 show v(n1+n150)  
689 at n100+21  
690 show v(n1+n150-20)  
691 calc n100+n100+200  
692 iplot
```

-- part:1, block=j -----

block 1j. *x06m1q8

```
694 unit x06m1q8  
695 restart  
696 calc n99=1,n99#2,n99#8  
697 jump n99,x,x,x,x06m1a  
  
698 entry x06m1q#8  
699 jump n99,x,x,x,x06min  
700 jump x06m1q  
701 ***
```

```
702 unit x06m1q  
703 next x06m2a  
704 at -505  
705 write At any instant,  $p_g(t) = p_R(t) + p_C(t)$ .
```

Over any period $0 < t < T$:
 $w_g(t) = k_p(t) + w_C(t)$

Graphs of $p_C(t)$, $w_C(t)$, $p_R(t)$, $w_R(t)$, $p_g(t)$, and $w_g(t)$ will be shown when you press -NEXT-.

```
710 pause  
711 erase  
712 calc y#85  
713 x#120  
714 *max#10  
715 ymax#200  
716 join x06s1b  
717 graph 1.5,200,p_C(t)  
718 graph 10,-20,t  
719 zdraw -10,0;-10,v60;-8,v61;-6,v62;-4,v63;-2,v64;0,0;0,v65;2,v66;4,v67;6,v68;8,v69;10,0  
720 calc y#85  
721 x#398  
722 ymax#50  
723 join x06s1b  
724 graph 1.5,50,w_C(t)  
725 graph 10,-5,t  
726 calc n111#60  
727 v112#v134#0  
728 n130#1  
729 n132#-8
```

```

730 calc v131e(v(60)-v(61))/4
731 doto 06m1q1a,v140+.25,1,.25
732 calc v133+v(61)+(1-v140)4(v131),
733 calc v112+v112+.025v133,
734 gdraw 2(v140-.25)-10,v134;2(v140)-10,v112
735 calc v134+v112
736 06m1q1a

737 entry x06m1q1
738 calc v131+(v(n111+n130)-v(n111+n130+1))/4
739 doto 06m1q2,v140+.25,1,.25
740 calc v133+v(n111+n130+1)+(1-v140+.25)4(v131)
741 calc v112+v112+.025v133
742 gdraw 2(v140-.25)+n132,v134;2(v140)+n132,v112
743 calc n130+n130+1
744 d06m1q2,
745 calc n132+n132+2
746 goto n132,x06m1q1,x
748 gdraw 0,v112;10,v112

749 entry x06m1q3
750 calc x#120
751 v#255
752 Vmax #200
753 join res1sp
754 calc x#398
755 Vmax #50
756 join res1sw
757 calc x#120
758 Vmax #200
759 v#425
760 join power
761 calc Vmax #50
762 x#398
763 join work

764 unit x06m2a
765 back x06m1p
766 next x06m2b
767 at 507.

```

Transients occur whenever a stable system is disturbed, so it behooves us to relate the wave-shapes you have just observed to the values of R and C in the equivalent circuit.

As with any dissipative system containing a single type of storage element, the differential equation which applies during any half-period in which the source voltage v_g is constant is

$$v_g(t) = R i(t) + \frac{1}{C} \int_0^t i(t) dt + V_{C0}$$

where V_{C0} is the capacitance voltage at $t = 0$, the beginning of that half-period.

Differentiating with respect to t gives the

762 first-order differential equation:

763

764 $R \frac{di}{dt} + \frac{1}{C} i = 0$

765 or

766

767 $\frac{di}{dt} = -\frac{1}{RC} i$

768

769

----- part=1, block=k -----

block 1k, x06m2b:

791 unit : x06m2b

792 back : x06m2a

793 next : x06m2c

794 at : 507

795 write The differential equation :

796

797 $R \frac{di}{dt} + \frac{1}{C} i = 0$

798 or

800

801 $\frac{di}{dt} = -\frac{1}{RC} i$

802 Solves to

804

805 $i = I_g e^{-t/RC}$

806 where I_g is the current at $t = 0$ and $e = 2.71828$,
807 the base of natural logarithms.

809 Any variable, whose rate of change at any instant
810 is proportional to the value of that variable at that
811 instant is of the natural exponential form, like i .

812 ***

813 unit : x06m2c

814 back : x06m2b

815 next : x06m2d

816 at : 507

817 write Consider the term

818 $e^{-t/RC}$

819 RC is called the time constant $\tau = RC$.

820 When $t = 0$, $e^{-t/RC} = e^{-0/\tau} = e^0 = 1.00$

821 When $t = \tau$, $e^{-t/RC} = e^{-\tau/\tau} = e^{-1} = 0.37$

822 When $t = 2\tau$, $e^{-t/RC} = e^{-2\tau/\tau} = e^{-2} = 0.14$
823 When $t = 3\tau$, $e^{-t/RC} = e^{-3\tau/\tau} = e^{-3} = 0.05$
824 When $t = 4\tau$, $e^{-t/RC} = e^{-4\tau/\tau} = e^{-4} = 0.02$
825 When $t = 5\tau$, $e^{-t/RC} = e^{-5\tau/\tau} = e^{-5} = 0.01$

826 Note that for any time $t_2 + t_1 + \tau$,

$$e^{-t_2/RC} = e^{-1} \times e^{-t_1/RC} = 0.37 e^{-t_1/RC}$$

828 In other words, during any time interval $\Delta t = \tau$
829 the exponential function concerned will decrease to
830 37 % of its value at the beginning of that interval.
831 ***

832 unit x06m2d
833 term test2
834 back x06m2c
835 next x06m2d1
836 at 1005

837 write Let's apply the above theory to measure the time
838 constant τ for the experimental RC circuit...

839 Turn the A PRE AMP to OFF, to provide a baseline
840 as we did before. Also, set TIME at 500 μ s and
841 B VOLTS at 1 V, so you display one half-period of
842 the current i.
843 ***

844 unit x06m2d1
845 pack n33,a0bc000000000c00+bd0000fad0000c00
846 join ckd
847 goto n47,x06s1c1,x06m2d2
848 ***

849 unit x06m2d2
850 pack n33,jfoc(cd)(de)edba< f(ritu)g(ab)>d(ef)(tu)+aaa++1
851 join ckd
852 jump n47,x06s1c1,x06m2e

----- part=1, block=1 -----

block 11, x06m2e:

854 unit x06m2e
855 back x06m2d
856 next x06m2f
857 at 1007
858 write Recall that 1 cm horizontally on this display
859 is now equivalent to 50 microseconds, and, beginning
860 at any point on the exponential curve, measure the
861 time interval in which the current i decreases

862 to 37 % of its initial value!

863 Time constant = τ = μs

864 arrow 1642

865 long 2

866 ansv 92,10

867 no

868 at 1705

869 write If the period of the current
870 is still 1 ms, your measurement
871 of τ should be in the range of
872 80 to 100 μs .

873 Try again, perhaps starting from some
874 other initial time on the smooth curve.

875 ***

876 unit x06m2f

877 back x06m2e

878 next x06m2g

879 at 505

880 write Another feature is significant for any first-order
881 exponential curve. Recall that

$$\frac{di}{dt} = -\frac{1}{RC} i = +\frac{1}{\tau} I_g e^{-\frac{t}{\tau}}$$

886 At any time t_1 , the tangent to the current curve is

$$\frac{\Delta i}{\Delta t}$$

887 Consequently, if a tangent to the current curve is
888 extend from time $t = t_1$ to $t = t_1 + \tau$, the tangent
889 line should end at $i = 0$.

890 Since this should apply at any point on the
891 decreasing curve, you now have another method of
892 graphically checking whether the curve represents a
893 first-order decreasing exponential function.
894 ***

895 unit x06m2g

896 back x06m2f

897 term test

898 at 205

899 write You should now be able to answer the following
900 questions pertinent to this experiment.

901 1. What element supplies the energy dissipated in R
902 during the second half-period when $v_g = 0$?

903 2. During the second half-period, $i = I_g e^{-t/\tau}$
904 wherein $I_g =$ mA

905 arrow 659

906 specs bumpshift

910 answer (c, cap, capacitor)
911 wrong (v_g, generator, source)
912 arrow 918
913 ansv -7.8,.5
914 inhibit erase
915 jump x06m2g1
916 ***

917 unit x06m2g1
918 next x06end
919 at 1105

920 write 3. During any half-period, the curve of p_R(t)
921 versus t is a first-order exponential function,

922 What is the time constant of p_R(t)?

923 calc x#248
924 y#205
925 Ymax #20
926 Xmax #10
927 join x06s1b
928 graph 1.5,20,p_R(t)
929 graph 1.5,-2,10
930 graph 9,-2,2000 usec.
931 funct (20) exp (-.6(v100)), v100#0,10,.5
932 at 1451
933 write usec
934 arrow 1444
935 ansv 40.5
936 wrong
937 join x06s2c

----- part=1, block=m -----

block 1m, x06s1a

939 unit x06s1a
940 at 1010

941 write The output voltage is displayed as it was in
942 earlier experiments. Just connect the adjustable
943 SQUARE OUTPUT of the Function Generator to A INPUT.

944 The circuit current is not as easy to measure.
945 The Scope is only capable of displaying a voltage
946 not a current. Using the basic equation v=iR,
947 the current can be measured by interpreting each
948 volt across the 100 ohm sampling resistor as
949 10 milliamperes. Therefore, monitor the voltage
950 at Terminal 3 and multiply it by 10 to read the
951 current in mA.

952 end
953 ***

954 unit x06s1b
955 origin x,y

956 axes -75,-75,75,75
957 scalex x_{max}
958 scaley y_{max}
959 markx 2x_{max},x_{max}/5
960 marky 2y_{max},y_{max}/5
961 end
962 ***

963 unit x06sic
964 next x06mie
965 erase
966 at 1007
967 write You have not followed my suggestions carefully.
968 Try again please..
969 ***

970 unit x06sic1
971 next x06m2d
972 erase
973 at 1007
974 write You have not followed my suggestions carefully.
975 Try again please..
976 ***

977 unit x06sicd
978 back x06mie
979 arrow n100
980 store v103
981 ansv v101
982 arrow n100+13
983 store v(n1-24)
984 ansv v102,.5
985 at n100+26
986 showt v103*x(n1-24)
987 calc n1+n1+1
988 v(n1)+v103*x(n1-25)
989 n100+n100+200
990 ***

991 unit x06sic
992 arrow n100
993 store v(n1-30)
994 ansv v102,2
995 at n100+10
996 showt v(n1)
997 at n100+21
998 showt v(n1-30)*v(n1)
999 calc v(n1-20)+v(n1+30)*v(n1)
1000 n1+n1+1
1001 n100+n100+200
1002 ***

1003 unit x06sicf
1004 next x06sicg
1005 at 519

1006 write
1007
1008 The graph you see below should look similar
to the traces displayed on the oscilloscope.
If it doesn't ask your instructor for assistance.

1009 entry graph
1010 origin 248,150
1011 axes -140,-140,140,140
1012 scalex 10
1013 scaley 10
1014 markx 2
1015 marky 2
1016 exit
1017 funct 10exp(-.25(10+v150)),v150<-10;10,.5
1018 gdraw -10,0;-10,10;10,10;10,0
1019 pause
1020 mode erase
1021 at 510

1022 write
1023 The graph you see below should look similar
to the traces displayed on the oscilloscope.
If it doesn't ask your instructor for assistance.

1024
1025 mode
1026 at 510
1027 write
1028
1029
1030
1031
1032
1033
1034 You can obtain five of the needed data points
from this display read the voltage values at
the • on the horizontal axis. Each data point
has a current and a voltage reading.

 Slide the base line up or down to read any
value that is off the screen. When you read
that value do not forget that the voltage is
from the new base line.

----- part=1, block=n -----

block in, x06end

1036 entry points
1037 graph -9.8,0,•
1038 graph -6,0,•
1039 graph -2,0,•
1040 graph 2,0,•
1041 graph 6,0,•
1042 exit
1043 ***

1044 unit x06sig
1045 at 510
1046 write For the other 5 data points the Trigger
Slope slide switch is used. Switch the
Trigger Slope to trigger on the negative
side of the wave. This will give you the
second cycle of the wave. The traces seen
on the scope should resemble the below graph.
1047
1048
1049
1050
1051
1052 join graph
1053 gdraw -10,0;-10,-10,

```

1054 funct -10exp(-.25(10+v150)),v150e-10,10,.5
1055 pause
1056 mode
1057 at
1058 write For the other 5 data points the Trigger
1059 Slope slide switch is used. Switch the
1060 Trigger Slope to trigger on the negative
1061 side of the wave. This will give you the
1062 second cycle of the wave. The traces seen
1063 on the scope should resemble the below graph.
1064 mode
1065 at
1066 write You can obtain the final five data points
1067 from this display read the voltage and current
1068 values at the • on the horizontal axis.
1069
1070 As before the base line can be moved up or
1071 join down to read values off the screen.
1072 end
1073 ***

1074 unit x06s2c
1075 at 2105
1076 write Known equations:
1077  $p_r(t) = R_t \times [i_c(t)]^2$ 
1078  $i_c(t) = I_{max} \times \exp[-t/\tau_1]$ 
1079 at 2505
1080 write Rearranging the equations:  $p_r(t) = R_t \times I_{max}^2 \times \exp[-2t/\tau_1]$ 
1081
1082 Now a different time constant,  $\tau_2$ , can be defined as  $\tau_1/2$ 
1083 This new time constant is the time constant for  $p_r(t)$ .
1084
1085 gdraw 0,20;2.2,0  $p_r(t) = R_t \times I_{max}^2 \times \exp[-t/\tau_2]$ 
1086 end
1087 ***

1088 unit x06end
1089 back x06m2g
1090 join imode
1091 jump n47,x06end,x
1092 course n2
1093 calc n2='ee244',
1094 nc(n21+1) < (nc(n21+1)$mask$07777777770000000000)+046030000000,
1095 nc(n21+1) & nc(m21+1)
1096 erase
1097 output /// student has completed experiment ///
1098 join
1099 join jmpmes
1100 jumpout cgeindex,quest1

1101 entry leave
1102 end lesson
1103 ***
1104 unit endunit
1105 course n2

```

1106	jump	n2m'ee244', leave, x						
1107	calc	nc(n21+7) <nc(n21+7) +ahelp						
1108		vc(n21+6) <vc(n21+6) +atime/68888						
1109	***Incl.	cge s.r. & terms sample, index, imode, comment, slides.						
1110	use	eex00, cki						
1111	use	ck2						
1112	use	ck3						
1113	use	ck4						
1114	use	ck5						
1115	use	ck6						
	ckc	not found	252	846				
	ckcw	not found	94	115	162	328	689	
	ckd	not found	258	851				
	ckdw	not found	100	121	168	326	689	
	endunit	x06end	1104	18	1098			
	graph	x06sia	1009	1052				
	imode	not found	29	1090				
	jmpmes	not found	1099					
	leave	x06end	1101	1106				
	points	x06end	1036	1071				
	power	x06m1i	411	768				
	replot	x06m1i	378	352				
	replotv	x06min	679	655				
	resisp	x06min	530	753				
	resisw	x06min	545	756				
	work	x06mik	441	763				
	x06end	x06end	1088	918	1091			
	x06m0a	x06m0a	27	30	50			
	x06m0b	x06m0a	49	31	72			
	x06mia	x06m0a	71	51	95	101	126	116 395 122
				697				
	x06mia1	x06mia1	92	73				
	x06mia2	x06mia1	98	96				
	x06m1b	x06mia1	104	102				
	x06m1b1	x06mia1	113					
	x06m1b2	x06m1af	119	117				
	x06mic	x06mia1	125	123	143			
	x06mid	x06mia1	142	127	163	169	174	
	x06mid1	x06mia1	160	144				
	x06mid2	x06mia1	166	164				
	x06mie	x06mie	172	170	216	263	964	292 978 332
	x06mif	x06mie	215	175				
	x06mif1	x06mie	250	248				
	x06mif2	x06mie	256	254				
	x06mig	x06mig	262	217	260			
	x06mih	x06mig	291	264				
	x06mih1	x06mig	311	293	312	324		
	x06mih2	x06mig	323	321				
	x06mii	x06mii	329	327	401	426		
	x06mii0	x06mii	393	379	380			
	x06mii1	x06mii	396	128				
	x06mij	x06mii	400	398				
	x06mik	x06mik	425	402	468			
	x06mik1	x06mik	449	459				
	x06mil	x06mik	465	429	504			
	x06min	x06min	503	469	586			
	x06min1	x06min	553	563				

x06m1m3	x06m1m	568	578				
x06min	x06min	584	585	681	687	619	699
x06min1	x06min	600	587				
x06min2	x06min	606	604				
x06m1o	x06min	612	610	636			
x06m1p	x06min	635	614	765			
x06m1q	x06m1q0	702	700				
x06m1q0	x06m1q0	694	615	638	688	681	
x06m1q0a	x06m1q0	698	128				
x06m1q1	x06m1q0	737	747				
x06m1q3	x06m1q0	749					
x06m2a	x06m1q0	764	703	792			
x06m2b	x06m2b	791	766	814			
x06m2c	x06m2b	813	793	834			
x06m2d	x06m2b	832	815	855	971		
x06m2d1	x06m2b	844	835				
x06m2d2	x06m2b	849	847				
x06m2e	x06m2e	854	852	877			
x06m2f	x06m2e	876	856	899			
x06m2g	x06m2e	898	878	1089			
x06m2g1	x06m2e	917	915				
x06s1a	x06s1a	939	74	145			
x06s1b	x06s1a	954	184	219	296	531	412
x06s1c	x06s1a	963	254	260	723	927	
x06s1c1	x06s1a	970	847	852			
x06s1d	x06s1a	977	357	359	961	968	363
x06s1e	x06s1a	991	372	374	376		
x06s1f	x06s1a	1003	659	661	663	669	665
x06s1g	x06end	1044	1004				
x06s2c	x06end	1074	937				
ahelp		1107					
atime		1108					
back		352	380	655	681		
exp		226	301	625	625	931	1017
		223					1054
key		352	380	655	681		
nc		1094	1094	1095	1095	1107	1107
nl		354	657	683	686	688	986
		987	988	988	993	996	997
		999	1000	1000		998	999
n100		353	656	682	685	687	691
		982	985	989	989	992	995
n111		445	450	450	452	549	556
		569	569	571	726	738	554
n120		176					565
n121		177					554
n122		178					551
n123		179					551
n130		447	450	450	452	457	457
		556	561	561	566	569	571
		728	730	730	740	745	745
n132		448	454	454	458	458	459
		562	562	563	567	573	573
		729	742	742	746	746	578

n149	417	419	419	421	422	423	684	690	686
n158	418	419	419	421	422	423	684	690	686
n2	1892	1893	1185	1186	1187	1187	1187	1187	1188
n21	1894	1894	1895	1895	161	257	167	319	251
n33	93	99	114	128	858				
	325	682	688	845					
n47	38	95	96	181	182	122	116	123	117
	163	164	169	178	254	307	268	694	321
	618	847	852	1091					
n94	221	222	222	226	226	340	226	344	299
	381	381	381	624	625	625	625	625	625
n95	228	222	226	227	227	625	628	626	625
	626	626							
n99	25	32	128	395	397	696	615	696	696
	697	699							
Pc	717								
Pc	297	414							
Pt	532	928							
Rr	186	223	297	298	414	444	415	532	443
t	533	547	548	621	622	724	717	725	718
	926								
v	419	450	450	452	554	589	554	562	556
	571	686	688	690	738	738	738	738	732
	748	983	986	988	988	998	993	998	996
	999	999	999						
vc	1108	1108							
v1	534	535	535	535	535	536	535	536	536
	536	536	557						
v100	226	226	201	381	625	921	625	931	625
v101	355	367	981						
v102	356	358	360	362	364	371	366	373	369
	375	658	660	662	664	670	666	672	668
	674	676	984	994					
v103	98	986	988						
v105	382	413							
v106	383	413							
v107	384	413							
v108	385	413							
v109	386	413							
v112	446	453	453	454	455	463	460	530	468
	557	557	558	559	564	572	564	573	572
	574	579	579	582	727	734	733	735	733
	741	741	742	743	748	748			
v131	450	452	554	556	569	732	571	738	730
	740								
v133	452	453	556	557	571	733	572	744	732
	741								
v134	446	454	455	558	558	574	559	727	573
	734	735	742	743					
v140	451	452	454	454	555	558	556	570	558
	571	573	573	731	732	737	734	740	734
	742	742							
v150	1017	1017	1054	1054					
v60	719								
v61	719								
v62	719								
v63	719								

v64		719								
v65		719								
v66		719								
v67		719								
v68		719								
v69		719								
v80		382	516	516	534	535				
v81		383	535							
v82		384	535							
v83		385	535							
v84		386	535							
v85		387	536							
v86		388	536							
v87		389	536							
v88		390	536							
v89		391	536							
v _E		186								
v _C		621								
w _C		724								
w _E		443								
w _T		547								
x		176	168	488	437	527	721	616	754	713
		754	757	762	923	955				
x _{max}		178	183	487	439	529	926	619	957	714
		959	959							
y		177	181	218	294	489	543	438	617	526
		712	728	751	759	924			955	
y _{max}		179	182	295	486	436	618	528	715	544
		722	752	755	758	761	960	925	960	958
μsec		419	422	1037	1038	1037	1040		1040	1041
		930								

lesson information

lesson name = eex06

starting date = 03/29/73

last edited on 08/21/74 at 11.26.37

by neal, of course eecge

at site 7, station 27

author name = J. P. Neal

department = EE

telephone number = 333-4351

discipline = EE

grade level = Freshman

description of lesson = Measurements of Transients.

----- part=1, block=a -----

block 1a, eex87id

2 stop
 3 **** For Neal, CGERL, Room 248, EEB.

4 One line description of this lesson --

5 Measurements of Impedance.

6 Divisions of this Lesson: Block Unit

7 Id for this file	eex87id
8 Experiment eex87;	
9 Objectives	
10 Measure impedance magnitude	x07m0a
11 Time displacement method	x07m1a
12 Lissajous figure method	x07m1d
13 Calc. impedance from components	x07m2a
	x07m2e
	x07m3a
	x07m4a
	x07m4a

14 final edit 21 aug 74 neal.

15 *list info
 16 *list symbols
 17 *list varian,charset,cgeindex,cgechar
 18 ****
 19 start
 20 finish endunit
 21 write {at,1010} Loading the CGE Character Set
 22 charset,cgeindex,cgechar
 23 erase
 24 zero n99 \$\$ used for restart skipping
 25 dataon "
 26 area eex87
 27 ext 0
 28 ***
 29 unit x07m0a
 30 restart
 31 join imode
 32 jump n47,x07m0a,x
 33 calc n55*-1 \$\$ used in review seq.
 34 calc n99*-1 \$\$ n99 = 0 if restart
 35 at 509
 36 write MEASUREMENTS OF IMPEDANCE

37 When you have completed this experiment, you
 38 should be able to:

- 39 1) Experimentally measure the magnitude of an
 40 impedance.

- 41 2) Measure the time-phase relation between two
 42 waveforms by the time-displacement method.
 43 3) Measure the time-phase relation between two
 44 waveforms by the Lissajous-figure method.
 45 4) Calculate the theoretical impedance of a
 46 series circuit and compare this value with the
 47 actual laboratory measurement.

----- part=1, block=b -----

block 1b, x07m1a

49 unit x07m1a
 50 base
 51 back x07m0a
 52 next n55,x07m1b,x07m3e
 53 at 387
 54 write

Consider a two-terminal electrical device driven
 by a single-frequency sinusoidal power source and
 having an input voltage v and input current i :

58 draw 198,391;248,391
 59 circle 8,227,375
 60 draw 166,375;219,375;skip;234,375;284,375
 61 at 921
 62 write
 63 at 1285
 64 write

When displayed on the SCOPE, the convenient
 measures of a sine wave are V_{pp} and the time angle
 after $t = 0$ at which the wave is positive-going
 through $v = 0$. We will use the input current i
 as the time reference, and thus show it by

$$i = I_{pp} \sin \omega t = 0.5I_{pp} \sin \omega t$$

Now, the input voltage leads or lags the input
 current by a time-angle equal to or less than $\pi/2$
 or 90° . Hence, the expression for the input voltage
 can be shown by

$$v(t) = V_{pp} \sin (\omega t + \theta) = 0.5V_{pp} \sin (\omega t + \theta)$$

where $-90^\circ \leq \theta \leq 90^\circ$.

78 unit x07m1b
 79 back x07m1a
 80 next x07m1b1
 81 at 585
 82 write

In terms of the input voltage and current of a

83 two-terminal circuit element, we will define the
84 impedance of that element by

85 $Z = |Z| \angle \theta$

86 where $|Z| = V_{pp} / I_{pp}$

87 θ = the angle by which the voltage
88 leads the current, as shown in the equations on the
89 preceding display.

90 Our present task is to measure $|Z|$, the magnitude
91 of the impedance of an inductive two-terminal circuit.

92 Select the IMPEDANCE BOARD, ITEM 35 from the
93 shelf below, and connect the sensor cable securely
94 in the panel connector below the Function Generator.

95 When you have connected the circuit-board sensor cable,
96 connect the circuit diagrammed on the next display.
97 ***

98 unit x07mib1
99 back x07mib
100 next x07mib
101 join x07s1a
102 pause.
103 pack n33,a0a0000000b0c0cabaa00000+00ba00
104 join ckc
105 jump n47,x,x07mic
106 pack n33,a0a0000000b0c0cabaa00000+00ba00
107 join ckc2w
108 ***

109 unit x07mic
110 back x07mib
111 join x07s1b
112 At 2007

113 write The connection diagram requires the display of
114 the voltage across the switch-selected impedance
115 on A channel of the SCOPE, and the voltage of the
116 current-sensing resistor on B channel, so

117 $|V_B| = |i_Z| \times 100$

118 Therefore: $|i_Z| = 10 \times |V_B|$ (milliamperes)
119 As connected, $V_B = -i_Z \times 100$. In order to display
120 $+i_Z$, set the B PRE AMP at AC.

----- part=1, block=c -----

block 1c, x07mid

122 unit x07mid

123 back x87mic
 124 next x87mid1
 125 at 787
 126 write Set the equipment so that:
 127 Two periods of a 2 kHz sine wave with $V_{pp} = 28$ V
 128 are displayed on channel A of the SCOPE.
 129 Externally trigger the SCOPE from the A INPUT
 130 for a stable display and use the AC EXT setting.
 131 Set the A PRE AMP at DC+, and the B PRE AMP at -DC.
 132 ***
 133 unit x87mid1
 134 next x87mid
 135 pack n33,+ (gh) (nop) d(cd) dc (ad) b+++++++(fg) <c (bc) b (uv) >+
 136 join ckw
 137 jump n47,x,x87mie
 138 ***
 139 unit x87mie
 140 back x87mid
 141 at 788
 142 write What is the value of I_{pp} ?
 143 milliamperes (mA)
 144 arrow 988
 145 ansr 2.9,.15
 146 wrongv .29,.015
 147 at 1518
 148 write For the current-sensing resistor
 149 $|I_{pp}|$ (milliamperes) = $|V_B$ pp | $\times 10$
 150 wrongv -2.9,.15
 151 at 1518
 152 write A peak-to-peak value cannot be a negative number.
 153 no
 154 at 1587
 155 write You should recall that $i_Z = -10 \times v_B$, where
 156 i_Z is in millamp and v_B is the voltage displayed
 157 on channel B. Be sure to set B VOLTS so that a
 158 large-size waveform is displayed on the CRT.
 159 endarrow
 160 at 1387
 161 write Recalling that $Z = \frac{V}{I}$, what is the magnitude
 162 of the impedance?
 163 $|Z| =$ k Ω
 164 at 1906
 165 write NOTE: As this experiment requires numerous calculations,
 166 a calculator is provided for your convenience.
 167 Simply enter the expression you need to evaluate.
 168 join x87s4e
 169 arrow 1713

178 ansv 7.14/.7

171 ***

172 unit x07m2a

173 back x07m1e

174 at 505

175 write Now that you have seen how to measure the magnitude
176 of an impedance, we will next measure the angle of
177 that impedance.

178 As stated earlier v and i have certain time angles
179 with respect to $t = 0$. We selected the time-reference
180 angle of the current as θ . Consequently, the time-
181 reference angle of the voltage is θ , the angle by which
182 the voltage leads or lags the current, that is, the
183 angle of the impedance.

----- part-i, block-d -----

block 1d, x07m2b.

185 unit x07m2b

186 back x07m2a

187 next n95, x07m2c, x07s2b

188 at 505

189 write We will now measure θ for the selected impedance
190 on the circuit board, by the time-displacement method.

191 If Δt is the time interval by which the voltage leads
192 the current, or the current lags the voltage, on the SCOPE
193 display, we can calculate θ using the following relations

$$i(t) = I_{gp} \sin \omega t$$

$$v(t) = V_{gp} \sin \omega(t + \Delta t) = V_{gp} \sin(\omega t + \theta)$$

$$\text{where } \theta = \omega \Delta t = 2\pi f \Delta t = 2\pi (\Delta t / T)$$

197 In the sinusoidal expressions, angles are in radians
198 and $\omega T = 2\pi$. However, in circuit calculations it is most
199 convenient to use angles in degrees, where 2π radians
200 is equivalent to 360° . Hence, to measure θ on the SCOPE
201 simple determine the fraction of the period T by which
202 the voltage leads the current and multiply that fraction
203 by 360° to evaluate θ . Incidentally, to type the
204 degree sign, simply press -MICRO- and type o.
205 ***

206 unit x07m2c

207 next x07s2a

208 back x07m2b

209 at 405

210 write Set the equipment so that:

211 The SCOPE is triggered externally by the A INPUT.
212 Both the A and B INPUTs are displayed in the A, Normal
213 mode, with the A PRE AMP at DC+ and the B PRE AMP at -DC.
214 With the B PRE AMP set in this manner, $i(t)$ will be
215 displayed rather than $-i(t)$.
216 The AUDIO OSCILLATOR should still supply $V_{pp} = 28$ V
217 at a frequency of 2 kHz to the A channel of the SCOPE.
218 It is not necessary to change any connections.
219 ***
220 unit x07m2d
221 base
222 jump n99,x,x07m3a
223 back x07m2c
224 next x07m2e
225 help x07s2b,
226 at 2410
227 write -HELP- is available.
228 at 505
229 write By what time interval does the current lag the voltage.
230 milliseconds.
231 arrow 705
232 store v60
233 ansv 0.08,0.02
234 at 905
235 write What is the period T of the sine waves, as
236 displayed on the SCOPE ?
237 milliseconds.
238 arrow 1205
239 store v61
240 ansv .5,.02
241 endarrow
242 vat 1305
243 write Recalling that $\theta = (\Delta t/T) \times 360^\circ$, what is θ ?
244 join x07s4e
245 arrow 1710
246 ansv (v60/v61)*360,2

----- part=1, block=e -----

block 1e, x07m2e

248 unit x07m2e
249 calc n51e-1 \$\$ used in x07m2f goto and writec
250 base
251 back x07m2d
252 next x07m2f
253 join x07s2c
254 join x07s2d

```

255 at 1126
256 write & LEADING waveform
257 at 1531
258 write & LAGGING waveform
259 pause
260 mode erase
261 join x07s2d
262 mode write
263 join x07s2e
264 pause
265 mode erase
266 join x07s2e
267 mode write
268 join x07s2f
269 ***

270 unit x07m2f
271 base
272 back x07m2e
273 lab x07s2d
274 help x07s2e
275 at 805
276 write Set the impedance-selector switch to position 5.
277 Is v(t) for this circuit leading or lagging?
278
279 at 1011
280 writec n51,,lagging      $$ inserts previous response
281 goto n51,x,x07m2f1
282 arrow 1010
283 answer lagging
284 no
285 at 1205
286 write Remember, v(t) is display on channel A; i(t)
287 on channel B. Press -LAB- to review the
288 definitions of leading and lagging.
289 endarrow
290 add1 n51

291 entry x07m2f1
292 at 1410
293 write Is θ positive or negative? _____
294 at 1438
295 writec n51,,,negative
296 goto n51,x;x,x07m2f2
297 arrow 1438
298 answer negative
299 no
300 at 1610
301 write θ for a a lagging v(t) is negative
302 endarrow
303 add1 n51

304 entry x07m2f2
305 at 1710
306 write Thus, this circuit is: _____ (type a,b,or c)
307
308 a) inductive

```

309 b) capacitive
310 c) resistive
311 arrow 1733
312 answer b
313 no
314 at 2309
315 write Press -HELP- for assistance and/or an explanation.
316 endarrow
317 at 2409
318 write Return the impedance selector switch to position
319 3 before proceeding.
320 ***

321 unit x07m3a
322 restart
323 base
324 back x07m2e
325 next x07m3b
326 help n99,x,x07s1a
327 data n99,x,x07m2c
328 at 1005
329 write The next method for measuring phase angles is
330 the Lissajous figure method. Before continuing,
331 however, recheck the balance of both SCOPE
332 channels and the positioning of the 0,0 point
333 on the SCOPE grid.
334 at 2010
335 writec n99@Press -HELP- to see the circuit diagram

Press -DATA- for dial settings.

----- part=1, block=f -----

block_if, x07m3b

\$\$ needed for proper use of x07s3a

337 unit x07m3b
338 zero n52
339 back x07m3a
340 next x07s3c
341 at 305
342 write To obtain a Lissajous figure from your
343 present circuit, set the Y DISPLAY FUNCTION
344 to A vs B and turn OFF the SWEEP MODE.

345 Press -NEXT- when you have finished.

346 Press -DATA- to see a typical Lissajous figure.

347 pause
348 keytype n51,data,next,back
349 goto n51,x,x07s3a,x
350 jump n51,x,x,x07s3c,x07m3a
351 ***

352 unit x07m3c

353 next x07m3d, x07m3e

354 back x07m3b

355 at 205

356 write The Lissajous figure on display is a plot of

357 $y = V_m \sin(\omega t + \theta)$ versus $x = I_m \sin \omega t$.

358 θ can be evaluated from the ratio of $M = 2V(t)$ at $t = 0$,

359 to $N = V_{pp}$. Thus:

360 entry x07m3c1

361 at 1007

362 write $2V_m \sin(\omega t + \theta)|_{\omega t=0} = 2V_m \sin(\theta+0)$

$$363 = \frac{2V_m \sin \omega t|_{\omega t=\pi/2}}{2V_m \sin 90^\circ} = \frac{M}{N} = \sin \theta$$

364 join x07s3a

365 join x07s3b

366 ***

368 unit x07m3d

369 base

370 next x07m3e

371 back x07m3c

372 help x07m3c1

373 calc n524-1

374 at 305

375 write From the Lissajous pattern displayed on the SCOPE,

measure:

377 M (t = 0) _____ Volts

378 N (at A_{max}) _____ Volts

379 θ (=arcsin M/N) _____ °

380 -HELP- is available

381 arrow 630

382 store v120

383 ansv 8.4,.6

384 arrow 630

385 store v121

386 ansv 10.1.1

387 no

388 at 1605

389 write A convenient method for measuring N is to turn
the B PRE AMP to OFF.

390 endarrow

392 join x07s3f

393 arrow 1030

394 ansv v102,5%

395 ***

396 unit x07m3e

397 base

398 at 405

399 write Recall our definition of impedance Z:

$$Z = |Z| \angle \theta$$

401 You should now be able to calculate the
402 magnitude, $|Z|$, and its phase angle θ .

403 Press -HELP- to review measurements of magnitude.

404 Press -DATA- to review the use of the time displacement
405 method in calculating θ .

406 Press -LAB- to review the use of the Lissajous
407 figure in determining θ .

408 Press -NEXT- to continue.

409 pause

410 keytype n55,next,back,help,data,lab

411 jump n55,x07m4a,x07m4a,x07m3d,x07mia,x07m2b,x07m3c

----- part=1, block=g -----

block 1g, x07m4a

413 unit x07m4a

414 imain x07s4g

415 at 405

416 write Thus far we have expressed impedance in the
417 polar form, $Z = |Z| \angle \theta$. Another representation is
418 the rectangular or complex form:

$$Z = R + jX \quad \text{where } j = \sqrt{-1}$$

420 in this expression, R is termed the resistive component
421 and X is called the reactive component.

422 For converting from the polar form to the rectangular
423 from, use of Euler's identity gives:

$$R = |Z| \cos \theta, \text{ and } X = |Z| \sin \theta$$

425 Similarly, to convert from the rectangular form
426 to the polar form, use the identities:

$$|Z| = \sqrt{R^2 + X^2} \quad \text{and, } \theta = \arctan (X/R)$$

428 Since these identities will be useful in the
429 remainder of this experiment, you may obtain
430 this display hereafter by pressing -SHIFT-DATA-.

431 Press -NEXT- to continue.

432 end

433 next x07m4b

434 ***

260

```

435 unit x07m4b
436 back x07m4a
437 at 505
438 write
439 For a SERIES circuit, R is the sum of the
440 resistances in the circuit. (Caution: this is
441 not true for a parallel circuit).
442 Individual series-element reactances are related
443 to the element parameters, i.e., capacitance and
444 inductance, and the frequency by the formulas:
445  $X_L = \omega L = 2\pi fL$  (recall  $\omega = 2\pi f$ )
446  $X_C = -\frac{1}{\omega C} = -\frac{1}{2\pi fC}$ 
447  $X = X_L + X_C$ 
448 These formulas will also be useful in the
449 remainder of this experiment; you may obtain this
450 display hereafter by pressing -SHIFT-LAB-.
451 end/
452 next x07m4c
453 ***
454 unit x07m4c
455 base
456 back x07m4c
457 next x07m4c1
458 at 605
459 write In a given circuit, one may measure either
460 R and X, or |Z| and  $\theta_Z$ , and expect the results
461 to be in agreement with one another.
462 Set the Impedance Selector Switch to position 2.
463 ***
464 unit x07m4c1
465 pack n33,aa00000000b0c0cab00000+00ba00
466 join clk
467 jump n17,x07m4c,x07m4d
468 pack n33,aa00000000b0c0cab00000+00ba00
469 join clk2w
470 ***
471 unit x07m4d
472 zero n59 $$ used in next goto and writec
473 base
474 back x07m4c
475 next x07m4e
476 help x07s4b
477 at 705
478 write Using the same 20 V p-p, 2 kHz signal from the
479 AUDIO OSCILLATOR, determine the magnitude of this
480 new impedance, Z.

```

481 |2| - k2

482 -HELP- is available
483 join x07s4e
484 arrow 1118
485 store v50
486 ansv 3.5, 10%

part=1, block=h

block.h, x07m4e

488 unit x07m4e
489 base
490 back x07m4d
491 next x07m4f
492 help x07s4d
493 lab x07s2e
494 at, - 705

495 write To complete this calculation of Z in the polar
496 form, $Z = |Z| \angle \theta$, determine θ by the time-
497 displacement method:

498 Recall that $\theta = \frac{\Delta t}{T}$

499 enter T = milliseconds

500 enter Δt = milliseconds

501 at 2420
502 write -HELP- is available
503 at 1318
504 writec n59,4s,v61,,
505 at 1518
506 writec n59,4s,v60,,
507 goto n59,x07m4e1,x
508 arrow 1316
509 store v61
510 ansv .5
511 no
512 at 1722
513 write Set the frequency so T = .5 ms.
514 endarrow
515 arrow 1516
516 store v60
517 ansv .04,.05
518 endarrow
519 calc n59e+1

520 entry x07m4e1
521 at 1910
522 write enter θ =
523 join x07s4e
524 arrow 1922,s
525 store v51

526 ansy $-(v60/v61) \times 360, 1$
527 wrongv $(v60/v61) \times 360, 1$
528 at 2185
529 write Recall that θ for a capacitive circuit is negative.
530 : Press -LAB- for an explanation.
531 ***

532 unit x07m4f
533 base
534 back x07m4e
535 next x07m4g
536 calc v52+sin(v51°)
537 calc v53+cos(v51°)
538 at 418
539 write You have calculated Z in the polar form as

$$Z = |(s, \sqrt{50}, k\Omega| \angle (s, \sqrt{51})^\circ$$

541 Using the identities available by pressing
542 -SHIFT-DATA-, express Z in the rectangular
543 form as $Z = R + jI$:

$$R = \text{_____} k\Omega$$

545 at 1616
546 write $\sin((s, \sqrt{51})^\circ) = (s, \sqrt{52})$.

$$547 \cos((s, \sqrt{51})^\circ) = (s, \sqrt{53})$$

548 at 1223

549 writec n59,,(s, \sqrt{54})

550 goto n59,x,x07m4f1

551 join x07s4e

552 arrow 1221

553 store v54

554 ansy v52+v50,10%

555 wrongv -v52+v50,10%

556 at 11237

557 write Units of Z and P are k Ω .

558 endarrow

559 zero n59

560 entry x07m4f1

561 at 1416

562 writec x = _____ k Ω

563 join x07s4e

564 arrow 1421

565 store v55

566 ansy v52+v50,10%

567 wrongv -v52+v50,10%

568 at 1437

569 write You need a minus sign.

570 no

571 at 1437

572 write Units of Z and X are k Ω .

part=1, block#1

block ii. x87m4g

576 unit x87m4g
577 base
578 back x87m4f
579 next x87m4h
580 help x87s4f
581 join x87s1b
582 at 144,428
583 erase 4
584 at 144,428
585 write •
586 at 428
587 write
588 catchup
589 at 27085
590 write Using the reactance equations which are available
591 by pressing -SHIFT-LAB-, calculate the theoretical
592 value of the impedance of circuit 2, and express
593 Z in rectangular form, R + jX
594
595 R = _____ k Ω
596 at 2514
597 write n59,,,(g,v56)
598 goto n59,x,x,x87m4g1
599 arrow 2511
600 store v56
601 ansy 3.3
602 wrongv 3.4
603 at 27085
604 write Voltage is measured between Terminal 15 and ground
605 Note that the 1000 resistor is not included in
606 this measurement. It is used only for sensing the
607 impedance current.
608 no
609 at 27085
610 write For a series circuit, P is the sum of resistors.
611 endarrow
612 calc n59e1 \$\$ avoids rewriting after branching key hit
613 entry x87m4g1
614 at 3083
615 write -HELP- is available
616 at 2532
617 write X' = _____ k Ω
618 join x87s4e
619 arrow 2536
620 store v57
621 ansy -1.6,10%
622 wrongv -1600,10%
623 at 3631
624 write Check your units.
625 wrongv 1.6,10%
626 at 3631
627 write Almost! You forgot the minus sign ..

628 ***

629 unit x07m4h

630 base

631 back x07m4g

632 next x07end

633 at 509

634 write You have measured the impedance of circuit

635 2 and expressed it in polar form as:

$$636 Z = |(s, v56) \text{ k}\Omega| \angle (s, v51)^\circ$$

637 You converted Z to the rectangular form and expressed

638 Z as:

$$639 \text{ (1) } Z = (s, v54) \text{ k}\Omega + j(s, v55) \text{ k}\Omega$$

640 Finally, you calculated the theoretical value of
641 Z in rectangular form and found:

$$642 \text{ (2) } Z = (s, v56) \text{ k}\Omega + j(s, v57) \text{ k}\Omega$$

643 If the measured value of Z, equation 1, differs
644 greatly from the theoretical value, equation 2,
645 you may wish to discuss the discrepancy with your
646 instructor. Bear in mind, however, that the values
647 of the components used to obtain equation 2 are rated
648 at +10%. Also, recall the inherent ± 3% error en-
649 countered when reading oscilloscope measurements.

----- part=1, block=j -----

block 1j, x07s1a

651 unit x07s1a

652 draw 310;337;737;713;313

653 circle 29,152,42

654 draw 341;349;649;841;241

655 circle 29,352,42

656 circle 3,351,42

657 circle 3,152,104

658 circle 3,348,390

659 circle 3,363,398

660 at 336,372

661 write 1

662 circle 3,288,416

663 circle 3,264,416

664 draw 1719;1741;2341;2319;1719

665 circle 3,160,298

666 circle 3,160,160

667 circle 3,304,176

668 circle 3,308,406

669 circle 3,264,406

670 at 261,380

671 write ↓
672 at 205, 308
673 write ↓
674 draw 1921; 1221; 1224; 624; 627; skip; 208, 406; 224, 406
675 224, 319; 352, 319; 352, 176; 304, 176; skip; 352, 398
676 352, 353; 104, 353
677 at 181, 349
678 write ◆
679 draw 2221; 2421; skip; 363, 389; 363, 128; 2421; skip; 634; 639
680 1139; 363, 336
681 at 368, 332
682 write ◆
683 at 2322
684 write IMPEDANCE BOARD
685 at 2137
686 write 15
687 at 2221
688 write 11
689 at 1922
690 write 1
691 at 536
692 write
693 at 633
694 write
695 draw 2221; 2233
696 at 256, 156
697 write ~~~~
698 draw 2237; 2239; 2139
699 at 248, 163
700 write 100Ω
701 at 1623
702 write current-sensing
703 resistor
704 at 268, 228
705 write
706
707
708
709 draw 1921; 1924; 1824; 1830; 2030; 2024; 1924; skip; 1930; 1939
710 2139
711 at 1905
712 write set switch to
713 connect
714 Term. 1 to 3
715 draw 109, 197; 160, 197.
716 at 159, 190
717 write →
718 at 1950
719 write NOTE:
720 AUDIO OSC.
721 ground strap
722 should be dis-
723 connected.
724 draw 949; 345, 368
725 at 342, 368
726 write ↑
727 draw 123, 432; 187, 432; skip; 520; 152, 460; 152, 403

728 at 1016
729 write $V_A \rightarrow$
730 at 929
731 write $V_B \rightarrow$
732 circle 3,232,406
733 draw 232,406;630;627
734 at 427
735 write trigger
736 input
737
738 at 221
739 write SET UP THIS CIRCUIT
740 at 2819
741 write Press -NEXT- when finished
742 end

----- part=1, block=k -----

block lk, x07s1b

744 unit x07s1b
745 circle 8,104;432
746 draw 515;519
747 at 144,428
748 write $\phi \rightarrow$
749 at 176,428
750 write \bullet
751 at 170,444
752 write \bullet
753 at 173,412
754 write \bullet
755 at 161,400
756 write \bullet
757 at 144,396
758 write \bullet
759 at 419
760 write
761 draw 147,397;147,368
762 at 1019
763 write
764
765
766 at 1013
767 write 3.3k Ω
768 at 1021
769 write $0.85\mu F$
770 draw 160,404;216,404;928
771 at 213,352
772 write \pm
773
774
775 at 1030
776 write .5H
777 draw 610;635;635

778 at 269,368
779 write
780
781
782
783 draw 524;530
784 at 232,428
785 write -
786 draw 534;543;943
787 at 353,352
788 write
789
790
791 at 1037
792 write 3.3kΩ
793 at 630
794 write .5H
795 draw 423;325;334
796 at 264,460
797 write -
798 draw 336;351;951
799 at 397,352
800 write
801
802
803 at 1045
804 write 3.3kΩ
805 at 256,444
806 write .05μF
807 circle 8,400,304
808 draw 1251;400,311
809 draw 1350;147,304;147,321
810 at 213,304
811 write
812 at 269,304
813 write
814 at 333,304
815 write
816 draw 400,296;1551;1545
817 at 320,268
818 write ~~~
819 draw 1541;1515
820 circle 8,104,272
821 at 320,276
822 write 100Ω
823 at 1352
824 write 15
825 at 1413
826 write 11
827 at 413
828 write 1
829 at 425
830 write 2
831 at 525
832 write 3
833 at 625
834 write 4

835	at	100,402
836	write	5
837	at	155,391
838	write	6
839	at	1724
840	write	ITEM 35
841	draw	1810;1855;155:110:1810
842	at	1422
843	write	current-sensing resistor →
844		
845	at	1712
846	write	V _A
847	at	313
848	write	V _A
849	draw	1352;1356
850	at	440,300
851	write	—
852	at	452,288
853	write	1

part=1, block=1

block 11, x07s2a

Note that both waveforms are adjusted to be symmetrical about zero volts.

```
883 hbar π/2, 1,-  
884 hbar 3π/2, -1,-  
885 hbar 3π/4, .5,-  
886 hbar 7π/4, -.5,-  
887 locate 0,.8  
888 write ←Δt→  
889 end  
890 ***  
  
891 unit x07s2c  
892 origin 1815  
893 axes 0,-128,256,128  
894 scalex 2π/  
895 scaley 1/  
896 labely 1,.25  
897 markx π,.25π  
898 funct sin(y70), √(y70), 2π, .02π  
899 funct sin(y70-.25π) × √(y70), 2π, .02π  
900 ***
```

```
901 unit x07s2d  
902 at 305  
903 write The following convention has been adopted  
904 regarding the sign of θ. Consider the  
905 positive going slopes of the two waveforms.  
906 The waveform whose peak appears on the left  
907 is said to LEAD the other. Correspondingly,  
908 the sinusoid whose peak appears on the right  
909 is said to LAG the other.  
910 end  
911 ***
```

```
912 unit x07s2e  
913 at 305  
914 write The impedance angle θ is defined as the  
915 angle of the voltage wave with respect to  
916 the current wave. Thus, if v(t) is leading,  
917 θ is positive (inductive circuit); if v(t) is  
918 lagging, θ is negative (capacitive circuit);  
919 if v(t) is neither leading nor lagging, θ  
920 is zero (resistive circuit),  
921 end  
922 ***
```

```
923 unit x07s2f  
924 at 305  
925 write Note that the voltage waveform (displayed  
926 on channel A) for this circuit leads the  
927 current waveform; thus, θ is positive, i.e.,  
928 an inductive circuit.  
929 ***
```

```
930 unit x07s3a  
931 calc v141+5j  
932 calc v141*(v141)0  
933 calc v141+abs(fv141)*.000001j  
934 calc |v141+cos(v141)/sin(v141)
```

```

935 origin 2132
936 axes -120,-120,120,120
937 scalex 5
938 scaley 5
939 markx 1.,5
940 marky 1.,5
941 calc v142+4/(sqrt(16-16(v141^2/(v141^2+1)))+4v141sqrt(v141^2/(v141^2+1)))
942 funct v142*(sqrt(16-v140^2)+v141*(v140)),v140<-4,+4,.1
943 funct -v142*(sqrt(16-v140^2)-v141*(v140)),v140<4,+4,.1
944 goto n52,x07s3b,x
945 end

```

part=1, block=m

block 1m, x#753b

Press **-NEXT-** to try again

979 Press -HELP- for a listing of your errors

```

980 Press -DATA- to see a typical Lissajous figure.
981 pause
982 keytype n51,data,next,help
983 goto n51,x,x07s3a,x
984 jump n51,x,x,x07m3b,x07s3e
985 ***

986 unit x07s3e
987 pack n33,(ij),(no)d+(de)ce+++++++(fg)<c(bcd)b(uv)>+
988 join ckd1w
989 pause
990 jump x07m3b
991 ***

992 unit x07s3f
993 at 2510
994 write ARCSIN CALCULATOR ( enter M/N )
995 arrow 2720
996 store v109
997 ansv v128/v121,5%
998 endarrow
999 calc v102+45°
1000 calc v101+0°
1001 calc v103+90°
1002 entry x07m3d1
1003 calc v110+v109-sin(v102)
1004 goto .0000001>abs(v110),x07m3d2,x
1005 calc 0>v110,v103+v102,v101+v102
1006 calc v102*(v101+v103)/2
1007 goto x07m3d1

1008 entry x07m3d2
1009 calc v102+(180/π)*v102
1010 at 2920
1011 write R1 = {t,v102}
1012 at 3115
1013 write Press -NEXT- to enter θ above
1014 pause
1015 ***

1016 unit x07s4b
1017 b1se
1018 at 705
1019 write Recall that the Y Display Function must be
      set to A & B ALT. Also, |Z| =  $\frac{|V_{pp}|}{|I_{pp}|}$ , where
      v is displayed on channel A, and channel B
      displays .i|i| where i is in milliamperes.
1020 at 1610
1021 write Press -NEXT- when you have correctly set the dials.
1022
1023
1024 at
1025 write
1026 pause
1027 pack n33,(ij)(fg)(no)d+(de)cdb+++++++(fg)<b(uv)c(bcd)>+
1028 join ckd1w
1029 next n47,x07s4b,x

```

1030 jump n47,x,x07s4c
1031 ***

1032 unit x07s4c
1033 next x07m4e
1034 at 707
1035 write |I_{pp}| = milliamps
1036 arrow 715
1037 ansv 5.7,10%
1038 no
1039 at 907
1040 write Recall that |i| = 10 |v_B|, where i is in milliamps.
1041 endarrow
1042 at 1011
1043 write |Z| = k Ω
1044 join x07s4e
1045 arrow 1018
1046 store v50
1047 ansv 3.5,10%

----- part=1, block=n -----

block in, x07end

1049 unit x07s4d
1050 next x07m4e
1051 help x07s4d
1052 data x07s2b
1053 at 1108
1054 write Press -HELP- for explanations on setting the dials.

1055 Press -DATA- for assistance in determining θ.
1056 ***

1057 unit x07s4d
1058 base x07s4d
1059 next x07s4d
1060 join x07m2c
1061 pause
1062 pack n33. (ij) (fgh) (ng)(cd)(de) cdb++++++ (fg) <b (uv) c (bcd) >+
1063 join cklju
1064 jump n47,x,x07m4e
1065 ***

1066 unit x07s4e
1067 mode erase
1068 at 3219
1069 write Press -NEXT- to enter your answer above
1070 mode write
1071 at 3837
1072 erase 20
1073 at 2938
1074 erase 15
1075 catchup

```

1076 draw 2717;2757;3057;3017;2717
1077 at 2819
1078 write CGE Calculator.
1079 Enter Expression:
1080
1081 arrow 2837
1082 store v100
1083 ok
1084 endarrow
1085 at 3038
1086 show v100
1087 at 3219
1088 write Press -NEXT- to enter your answer above
1089 pause
1090 ***
1091 unit x07s4f
1092 at 511.
1093 write The important equation for use in calculating
1094 the reactance, X, is:
1095
1096  $jX_C = \frac{1}{j\omega C} = j \left( -\frac{1}{2\pi f C} \right)$ 
1097
1098 where  $f = 2,000$  Hz.
1099
1100 'π', if you would prefer to use the symbol,
is obtained by pressing -MICRO- then pressing -p-.
1101
1102 Note that your answer is requested in units
1103 of  $\text{k}\Omega$ , where  $k = 10^3$ . The capacitance shown on
1104 the diagram is rated in units of  $\mu\text{F}$ , where  $\mu = 10^{-6}$ .
1105 end
1106 ***
1107 unit x07s4g
1108 data1 x07m4a
1109 label x07m4b
1110
1111 unit x07end
1112 back x07m4a
1113 join imode
1114 jump n47,x07end;x
1115 course n2
1116 calc n2='ee244',
1117 nc(n21+1) < (nc(n21+1) $mask$07777777770000000000) + 04603000000,
1118 nc(n21+1) & nc(n21+1).
1119 erase
1120 output /// student has completed experiment ///
1121 join endunit
1122 join jmpmes
1123 jumpout cgeindex,quest1
1124 entry leave
1125 end lesson
1126 ***

```

```

1126 unit endunit
1127 course n2
1128 jump n2#`ee?44', leave, x
1129 calc rc(n21+7) <= nc(n21+7) +ahelp
1130 vc(n21+6) <= vc(n21+6)+atime/60000
1131 ***Incl. oge s.r. & terms sample, index, imode, comment, slides.
1132 use eex00, ckl
1133 use ck2
1134 use ck3
1135 use ck4
1136 use ck5
1137 use ck6
ckc not found 104 466
ckcw not found 866 967
ckc2w not found 107 469
ckd not found 858 964
ckdiw not found 136 1028 1063
ckd1w not found 861 988
endunit x07end 1126 20 1120
imode not found 31 1112
jmpmes not found 1121
leave x07end 1123 1128
x07end x07end 1110 632 1113
x07m0a eexx07id 29 32 51
x07m1a x07m1a 49 79 411
x07m1b x07m1a 78 52 99 100 118
x07m1b1 x07m1a 98 88
x07m1c x07m1a 109 105 123
x07m1d x07m1d 122 134 140
x07m1d1 x07m1d 133 124
x07m1e x07m1d 139 137 173
x07m2a x07m1d 172 166
x07m2b x07m2b 185 208 411
x07m2c x07m2b 206 187 223 327 856 1004 864
x07m2d x07m2b 207 251 867
x07m2e x07m2e 248 224 272 324
x07m2f x07m2e 270 252
x07m2f1 x07m2e 291 261
x07m2f2 x07m2e 304 296
x07m2a x07m2e 321 222 339 350
x07m3b x07m3b 307 325 354 970 974 990 984
x07m3c x07m3b 352 371 411 968
x07m3c1 x07m3b 368 372
x07m3d x07m3b 368 353 411
x07m3d1 x07m3b 1002 1007
x07m3d2 x07m3b 1008 1004
x07m3e x07m3b 396 52 353 370 870
x07m4a x07m4a 413 411 411 436 1107 1111
x07m4b x07m4a 435 433 1108
x07m4c x07m4a 454 452 456 467 474
x07m4c1 x07m4a 464 457
x07m4d x07m4a 471 467 498
x07m4e x07m4a 488 475 534 1033 1050 1064
x07m4e1 x07m4a 520 507
x07m4f x07m4e 532 491 578
x07m4f1 x07m4e 562 552

```

x07m4g	x07m4g	576	535	631
x07m4g1	x07m4g	613	598	
x07m4h	x07m4g	629	579	
x07s1a	x07s1a	651	101	326
x07s1b	x07s1b	744	111	581
x07s2a	x07s2a	855	207	
x07s2a1	x07s2a	963	859	
x07s2b	x07s2a	869	187	225
x07s2c	x07s2a	891	253	880
x07s2d	x07s2a	981	254	261
x07s2e	x07s2a	912	263	266
x07s2f	x07s2a	923	268	274
x07s3a	x07s3a	938	349	365
x07s3b	x07s3b	947	366	948
x07s3c	x07s3b	962	340	350
x07s3d	x07s3b	972	965	
x07s4e	x07s3b	986	975	984
x07s3t	x07s3b	992	392	
x07s4b	x07s3b	1016	476	1029
x07s4c	x07s3b	1032	1030	
x07s4d	x07end	1049	492	1059
x07s4d1	x07end	1057	1051	
x07s4e	x07end	1066	168	244
			1044	483 565 523 610 559
x07s4f	x07end	1091	580	
x07s4g	x07end	1106		
abs		933	1004	
ahelp		1129		
atime		1130		
cos		537	934	
n9		1116	1116	
n2		1114	1115	
n31		1116	1116	
n33		1093	1096	
n47		986	967	
n51		34	105	
n52		1030	1064	
n55		290	280	
n59		350	350	
n99		33	33	
sqr		35	52	
sqrt		472	504	
vc		590	612	
v100		34	34	
v101		536	898	
v102		941	942	
v103		1130	1130	
v104		1082	1060	
v105		1000	1005	
v106		394	999	
v107		1061	1065	
v108		986	1003	
v110		1003	1004	
v120		382	997	
v140		385	997	
v141		942	942	
		931	932	
			932	933
			933	934
			934	934
			934	934

v141sqr	941	941	941	942	943		
v142	941	942	943	568	569	636	1846
v58	485	548	556	547	549	636	
v51	528	548	547	549	549	636	
v51°	536	537	568	569	569		
v52	516	547	556				
v53	517	549	556				
v54	551	555	539				
v55	567	639					
v56	547	600	642				
v57	611	642					
v68	246	506	516	526	527		
v61	246	504	589	526	527		
v70	898	899	899				
	406	556	568	569	625	621	497 622
A	1037	1047					
B	957						
C	958						
D	883	884	885	886			
E	892						
F	912	933	999	1000	1001		
G	812	883	884	885	886	897	894 898 897
H	848	849	849	899	1000		

lesson information

lesson name = eex07

starting date = 04/11/73

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by Neal of course eecge

at site 17, station 18

author name = J P Neal

department = EE

telephone number = 333-4351

discipline = EE

grade level = Freshman

description of lesson = Measurements of Impedance.

lesson eex08 at 18:39 pm on wednesday, august 28, 1974

----- part-1, block-a -----

block 1a, eex08id

2 stop
3 exec For Neal, CGERL, Room 248, EEB.

4 One line description of this lesson --

5 Measurements of Two-Port Networks.

6 Divisions of this Lesson:

7 Id for this file

8 Experiment eex08

9 Objectives,

10 Definition of two-port network

11 Voltage gain of a two-port

12 Frequency response of two-port

13 Final test

Block	Unit
eex08id	x08m0a
	x08m1a
	x08m2a
	x08m3a
	x08m4a

14 final.edit 21 aug 74 Neal.

15 *list info
16 *list symbols
17 *list variab,charset,cgeindex,cgechar
18 ***
19 start
20 finish endunit
21 write tgt,(010) Loading the CGE Character Set
22 charset cgeindex,cgechar
23 erase
24 datapn
25 area eex08
26 ext n

----- part-1, block-b -----

block 1b, x08m0a,

28 unit x08m0a
29 next x08m1a
30 define x08def
31 err=n50
32 errmess=n51
33 it=n52 \$\$ specifies input terminal of two port
34 ot=n53 \$\$ specifies output terminal of two port
35 f0=v55
36 f0=v56
37 zero err

38 restart.
39 join 1 mode
40 jump n47,x88m8a,x
41 at 41
42 write MEASUREMENTS OF TWO-PORT NETWORKS
43 at 785
44 write When you have completed this experiment, you should
45 be able to:

- 46 1. Understand the definition of a two-port network.
- 47 2. Measure the voltage-gain transfer function of a
48 two-port network.
- 49 3. Measure the frequency response of the voltage
50 gain of a two-port network.
- 51 4. As a final test, measure the frequency response
52 of the voltage gain of a band-pass filter.

----- part=1, block=c -----

block 1c, x88m1a

54 unit 1 x88m1a
55 back x88m8a
56 next x88m1b
57 at 187
58 write Throughout this lesson we will represent a network
59 by a box which may be thought of as containing the
60 network.

61 Leads brought out of the box indicate that
62 certain terminals or nodes of the network are
63 externally accessible. That is, we can connect to
64 or measure between these terminals or nodes.

65 draw 1723;1742;2348;2323;1723;2123;2117;skip;1923;1917
66 skip;1942;1948;skip;2142;2148;skip;2335,2735
67 skip;2730;2330

68 at 219,187
69 write NETWORK

70 circle 3,128,208

71 circle 3,128,176

72 circle 3,376,176

73 circle 3,376,208

74 circle 3,232,80

75 circle 3,272,80

76 vector 252,41;272,80

77 vector 252,41;232,80

78 at 206,21

79 write TERMINALS

80 ***

81 unit x88m1b

82 term m1b
83 back x88m1a
84 next x88mic
85 at 307
86 write . A pair of terminals is called a port. A two-port
87 network is, therefore, a network with two pairs of
88 external terminals.

89 In a two-port network, one of the ports is usually
90 connected to a source, and the other port is usually
91 connected to a load.

92 For the arrangement shown below, the following
93 four electrical quantities can be measured:

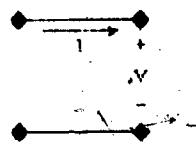
$$I_1, V_1, I_2, \& V_2.$$

94
95 join x88s1a
96 join x88s1b
97 join >x88sic
98 at 2705
99 write . Throughout this experiment, we will assume that the
100 impedance Z_L is a very high impedance, i.e., that the
101 magnitude of I_2 is small compared to the magnitude of I_1 .

----- part-1, block-d -----

block 1d, x88mic

103 unit x88mic
104 back x88m1b
105 next x88mid
106 at 307
107 write Consider any port, or pair of terminals, in a network
108 driven by a single-frequency sinusoidal power source.
109 Conventions used here for the voltage and current are:



110
111
112
113
114 When displayed on the SCOPE, the convenient measures
115 of a voltage are V_{pp} and the time angle ϕ_V after $t = 0$,
116 where the voltage is positive-going through $v = 0$.

117 Then, the voltage is expressed mathematically by:

$$v(t) = 0.5V_{pp} \sin(\omega t + \phi_V) = V_{pp} \sin(\omega t + \phi_V)$$

118 Here, this voltage is expressed as a phasor by:

$$V = |V| \angle \phi_V \text{ where } |V| = 0.707 V_{pp}$$

122

Similarly, the current representations are:

$$123 \quad i(t) = I_{pp} \sin(\omega t + \phi_i), \quad I = |I| \angle \phi_i, \quad |I| = 0.707 I_{pp}$$

124 ***
 125 unit x08mid
 126 back x08m1c
 127 next x08m2a
 128 at 505

A transfer function is a relation between two activities at two different ports in a network. This contrasts with an impedance function which is a relation between two activities at the same port in a network.

133 The transfer function called the voltage gain is
 134 of interest in this experiment. We will refer to it
 135 hereafter simply as the gain G and define it by:

$$136 \quad G = |G| \angle \phi_G = V_2 / V_1 = (|V_2| / |V_1|) \angle (\phi_{V_2} - \phi_{V_1})$$

137 The gain is a complex quantity and can also be
 138 written in complex form, like we did for impedances
 139 in the impedance experiment, as:

$$140 \quad G = G_{re} + j G_{im}$$

part=1, block=e

block ie, x08m2a

142 unit x08m2a
 143 back x08mid
 144 next x08m2b
 145 at 405

146 write Now consider the two-port shown below, where port 1
 147 is the driven port, and port 2 is the load port.

148 If $V_1 = 15$ V dc and $V_2 = 3$ V dc, what is the gain G ?

149 join x08s1a

150 join x08s1c

151 join x08s1b

152 arrow 926

153 at 926

154 write

155 ansv .20,.05

156 wrong 3

157 at 1111

158 write No, the gain of the two-port is defined as the ratio V_2/V_1 .

159

160 ***

161 unit x08m2b

162 back x08m2a

163 next x08m2c

164 help x88s2a

165 at 305

166 write Now suppose you are given another two-port network.

167 $V_{1pp} = 10 \angle 0^\circ$ V drives port 1.

168 V_2 is then measured as $V_{2pp} = 5 \angle +31^\circ$.

169 What is the voltage gain G of the two-port in polar form,
i.e., in the form $|G| \angle \alpha^\circ$? (Press -MICRO- then o for $^\circ$.)

171 join x88s1a

172 join x88s1b

173 join x88s1c

174 at 1210

175 write Magnitude _____ Phase angle _____

176 at 3122

177 write -HELP- is available.

178 arrow 1220

179 ansy 1240

180 arrow degrees, deg, ° > 31

181 answer degrees, deg, ° > -31

182 write

183 write

184 unit x88m2a

185 back x88m2b

186 next x88m2d

187 help x88s2b

188 at 405

189 write

Consider the resistive two port network shown below.

190 If $V_1 = 10$ V dc, what is V_2 and G.

191 $V_2 =$

192 at 817

193 write V dc.

194 at 830

195 write G =

196 join x88s1d

197 join x88s1a

198 join x88s1c

199 at 3122

200 write -HELP- is available

201 arrow 817

202 ansy 5

203 no

204 at 1005

205 write Hint! Think of the two-port network as a simple
voltage divider. Note also that -HELP- is available.

206 arrow 833

207 ansy 15

208 no

209 at 1011

210 write You got V_2 correct, now simply use the formula
 $G = V_2 / V_1$ to find the voltage gain.

----- part=1, block=f -----

block if. x86m3d

214	unit	>08m2d
215	back	>08m2c
216	next	>08m2e
217	calc	its1
218		ct#3
219	at	+05

Let's try to verify this last result experimentally. The resistive two-port just studied is part of the superposition circuit. Plug in the sensor cable in the SUPERPOSITION BOARD, ITEM 38, and place all the switches on the board (SW1 through SW4) in the superposition.

You should now have the following two-port network:

226		You
227	join	23081
228	join	23081a
229	join	23081c
230	at	2317
231	write	1
232	at	2343
233	writes	
234	at	2316
235	white	11
236	at	2347
237	write	11
238	pause	
239	at	2320
240	write	1
241	at	2345
242	white.	In
243		common
244	*xx	

In this experiment, terminal 1 is used as the common grounded terminal.

245 unit x00m2e
246 back x00m2d
247 next x00m2f
248 calc 0r m3ssed
249 zero 0rr
250 join x03s2h
251 end
252 ***
253 Unit x00m2f
254 pack n33,++efhet++a++t+a (abcd)+aaaa++
255 join ckd >
256 jump h47,x00s2c,x
257 entry x00m2g
258 pack n33,aacdd0cc00k0klllac00000000ak00
259 join chc
260 calc errmesses

261 erren47
262 jump n47,x08s2d,x08m2h
263 ***

264 unit x08m2h
265 erase
266 catchup
267 back x08m2d
268 next x08m2j
269 zero err
270 rat 405
271 write

Measure the gain of the two-port by setting the following dials:

273
274
275
276
277 1) Set the OSCILLOSCOPE to display a 1 kHz sine wave with an amplitude in the range $5 \leq V_{pp} \leq 10$ V. Set the Y DISPLAY to A, the A PRE AMP to +AC, the TRIGGER SOURCE to AC INT, and the SWEEP MODE to AUTO.

278
279 2) Set the RANGE control of the VACUUM TUBE VOLTMETER to 3 RMS VOLTS.

280
281
282
283
284
285
286
287
288 3) Adjust the frequency controls of the AUDIO OSCILLATOR to produce a 1 kHz sine wave output. Temporarily connect the VTVM INPUT to terminal {z, ot} of the two-port network and then adjust the AMPLITUDE dial of the AUDIO OSCILLATOR to give a 2 rms V reading on the VTVM.

289
290
291
292
293
294 4) Now reconnect the VTVM INPUT to terminal {z, ot} of the two-port network.

295 end
296 join x08m2i
297 ***

298 unit x08m2i
299 at 2005
300 write After setting these dials, press -NEXT-.
301 ***

302 unit x08m2j
303 pack n33,+ (gh) mecfbab+++++++(bc) b (fg) h
304 join ckd
305 calc errmess#0
306 erren47
307 jump n47,x08s2f,x08m2k

part=1, block=g -----

block 1g, x08m2k.

304 next x08m21

305 at 405

306 write You have now correctly set up the two-port network
307 for gain measurements. Without changing the
308 AMPLITUDE dial of the AUDIO OSCILLATOR at all;
309 measure the output port voltage (terminal 3) on the VTVM.

310 What is value that you read on the VTVM?

311 arrow 1110

312 at 1110

313 write rms V

314 store v52

315 ansy 1.5%

316 at 1605

317 write 318 The input voltage V_1 to the two-port network was
set above to 2 rms V.

319 The output voltage, V_2 , that you obtained was
320 42, v52 > rms V.

321 What is the voltage gain of the two port?

322 arrow 2417

323 ansy x52/2.5%

324 v52/2.5%

325 at 1605

326 write Remember the voltage gain of a two-port is defined
327 as V_2/V_1 , not V_1/V_2 !!!

328 at 2405

329 write You have miscalculated the voltage gain G.
330 Check again to make sure that V_1 is 2 rms V,
331 and remeasure the output port voltage, V_2 .

332 write x08m21

333 mode

334 batchup

335 back x08m2k

336 next x08m2n

337 at 805

338 write Now vary the frequency of the AUDIO OSCILLATOR, making
339 sure to keep the input voltage V_1 constant as you do this.

340 entry x08m2m

341 at 1305

342 write It may be helpful to first set V_1 to 2 rms V, at a
343 particular frequency (e.g. 1 kHz). Then, with A VOLTS
344 FULL SCALE set to 5 V, take the A AMP off of
345 calibration. This is done by rotating the red knob
346 marked VARIABLE GAIN counter-clockwise.

347 By adjusting the VARIABLE GAIN, set the peak-to-peak
348 deflection on the SCOPE to exactly 10 divisions and leave
349 it there.

352 Thereafter, as you rotate the frequency dial of the
353 AUDIO OSCILLATOR, readjust only the AUDIO OSCILLATOR
354 AMPLITUDE control to maintain a constant peak-to-peak
355 deflection on the SCOPE.
356 end.

----- part=1, block=h -----

block 1h x08m2n

358 unit x08m2n
359 back x08m21
360 next x08m20
361 lab x08m2m
362 at 805
363 write Do you notice any change in the amplitude of the
364 output voltage on the VTVM, as the input frequency
365 to the two-port is varied?
366 arrow 1220
367 answer (n, no, N, No)
368 at 1485

369 write Right! As long as the input amplitude to a resistive
370 two-port is held constant, the output voltage
371 amplitude will not vary as a function of frequency.
372 This is because the impedance of a resistor is
373 independent of frequency and hence the voltage
374 gain of a resistive two-port is independent of
375 frequency.

376 wrong (y, yes, Y, Yes, some)
377 at 1485
378 write Make sure that you keep the input voltage
379 to the two-port constant as you vary the frequency.
380 Press -LAB- if you need a hint on how to do this.
381 ***

382 unit x08m20
383 at 805
384 write If you have taken the A VOLTS off of calibration
385 by adjusting the red VARIABLE GAIN knob, place
386 the A VOLTS back into calibration by rotating
387 the red VARIABLE GAIN dial fully clockwise until
388 it clicks.

389 When the A channel is in its calibrated mode,
390 the A VOLTS window will be lit.
391 pause

392 entry x08m2p
393 join imode
394 jump n47, x08m2p, x08m3a

----- part=1, block=i -----

block 1i, x08m3a

396	unit	>#8m3a
397	back	>#8m2n
398	next	>#8m3b
399	base	
400	at	405
401	write	Plu
402		ITEM 3

11. Plug the sensor cable of the TWO PORT NETWORK BOARD, ITEM 36, into the interface.

In this part of the experiment, the two port concerned consists of a series capacitor and a shunt resistor. The input port is terminals 1 & 2 and the output port is terminals 3+ 2. Terminal 2 will be used as the ground terminal. Locate these terminals on the board now.

410	unit	•008m%
411	zero	•000m%
412	back	•000m%
413	next	•000m%
414	join	•000m%
415	end	•000m%

part=1, block=j

block 1j xflam3c

~~Set the equipment dials to the same positions you previously used for measuring the gain of the resistive two port.~~

~~Press -DATA- to review the dial settings necessary~~

OR

436 . . . Press -NEXT- after you have properly set the dials.
437 ***

438 unit x08m3e
439 pack n33,++m+cfbab+tt++++bb (pq) h
440 join ckd
441 calc errmess#1
442 err#n17
443 jump n47,x08s2f,x08m3f
444 ***

445 unit x08m3f
446 back x08m3d
447 next x08m3g
448 data x08m2m
449 at 405
450 write Now, monitoring the output port with the VTVM,
451 vary the AUDIO OSCILLATOR frequency over the range
452 of 20 Hz to 100 Hz, while keeping the voltage
453 amplitude at the input port constant.
454 at 905

455 write Press -DATA- for a hint on keeping the input
456 port voltage amplitude constant!

457 at 1405
458 write Does the output voltage vary as a function of
459 frequency?
460 arrow 1524
461 answer (Y,Y,Yes,Yes)
462 at 1705

463 write Right! If the input port/voltage V_1 is held
464 constant, the output port voltage V_2 will vary as
465 a function of frequency.

466 Our next goal will be to predict the frequency response
467 of the gain of a simple two-port RC network.

468 write Leave your equipment setup alone, as it will be
469 used later.

470 wrong (In,N,no,Mp)

471 at 1718

472 write Make sure that you are keeping the input
473 port voltage constant and that you are varying
474 the AUDIO OSCILLATOR over the correct frequency
475 range.
476 ***

477 unit x08m3g
478 back x08m3f
479 next x08m3h
480 lab x08s2b
481 at 405

482 write The gain G of the two port you have just connected
483 may be analyzed easily by using the voltage-divider
484 concept, where impedances are used instead of resistances.

485 When I_2 is negligible with respect to I_1 , the gain
486 of the two-port under study, is approximated by:

487 $G(j\omega) = \frac{V_1}{V_2} = \frac{j\omega RC}{1 + j\omega RC}$

489 where $R = 2 \text{ k}\Omega$, $C = .1 \mu\text{F}$, and $\omega = 2\pi f$.

490 Note that the gain is now a function of frequency,
491 and may be designated by $G(j\omega)$.

492 To review the voltage divider concept, press -LAB-.

493 We will now measure $G(j\omega)$ as a function of frequency.

part=1, block=k

block ik, x08m3h

495 unit x08m3h
496 back x08m3g
497 next x08m3i
498 at 405
499 write

The magnitude of $G(j\omega)$ in decibels (abbreviated dB)
is defined by $|G(j\omega)|_{\text{dB}} = 20 \times \log_{10} |G(j\omega)| \text{ dB}$

501 The advantage of using the decibel or logarithmic
502 notation is that it permits the easy computation
503 of the magnitude of a product of gain functions, by
504 simply adding the individual decibel values, i.e.,

505 $|G_1(j\omega) G_2(j\omega)|_{\text{dB}} = |G_1(j\omega)|_{\text{dB}} + |G_2(j\omega)|_{\text{dB}}$

506 It may also be noted that the phase angle of the
507 product of two gains is simply the sum of their angles:

508 $\angle G_1(j\omega) G_2(j\omega) = \angle G_1(j\omega) + \angle G_2(j\omega)$

509 The measurement of $|G|_{\text{dB}}$ is facilitated by the
510 use of the VTVM's dB scale. The use of this scale
511 in measuring $|G|_{\text{dB}}$ will be covered next.
512 ***

513 unit x08m3i
514 back x08m3h
515 next x08m3j
516 at 204
517 write

USE OF THE dB SCALE ON THE HP400D VTVM

518 A decibel is defined as $20 \log_{10} a/b$, i.e., 20 times
519 the log to the base 10 of the ratio of two numbers.

520 For our use (finding the gain of a two-port), the
521 dB scale on the VTVM makes gain measurements easy.

522 The dB scale on the VTVM is calibrated in terms of the
523 ratio of the measured voltage V_2 to the reference voltage.
524 The reference voltage used on the VTVM is $V_r = 0.775$ rms V.
525 Hence, the dB reading on the VTVM of any voltage is

526 $|V_x|_{dB} = 20 \log_{10} |V_2/V_r| = 20 \log_{10} |V_x| + 20 \log_{10} |0.775|$

527 In making a gain measurement, it is convenient to set
528 the VTVM to the proper voltage scale to read $|V_2|$, but
529 before reading it, readjust " until the pointer indicates
530 0 dB on the dB scale. Then the value of $|V_x|_{dB}$ is that
531 same, in dB, plus the value on the RANGE dial setting.

532 Next, without further adjusting V_1 , measure V_2 on
533 the off scale, adjusting the RANGE switch so as to give
534 the most accurate reading. Then, $|V_x|_{dB}$ is the sum of
535 the off scale reading and the dB RANGE label. Finally

536 $|V_x|_{dB} = |V_2|_{dB} + |V_1|_{dB}$

537 end

----- part=1, block=1 -----

block 11, >08m3)

548 unit >08m3
549 base
550 back
551 front
552 ext
553 lab
554 at
555 write

Now measure the frequency response of $|G|_{dB}$:

556 1) At 5 kHz, adjust the A.O. AMPLITUDE dial so that
557 the VTVM, which is currently displaying V_2 , reads
558 0 dB, when the RANGE dial is set to +10 dB.

559 2) Now keeping V_1 constant, decrease the frequency
560 of the A.O. until the gain is down 3 dB from its
561 5 kHz value.

562 Press <LAB> for a suggestion on keeping V_1 constant.

563 At what frequency is the gain down 3 dB? Hz.

564 arrow 1640
565 store f_c
566 ansy 66.5,5%
567 ariong
568 at 1805

569 write The frequency at which $|G|_{dB}$ is down 3 dB from its
570 high frequency value is known as the corner frequency,
571 f_c, of the two port.

572 ***

563 unit x08m3k
564 back v08m3j
565 at 410.
566 write Measure $|G|_{dB}$ at .5,.7,1,2,3,5,& 10 times f_o .

567 FREQUENCY (Hz) $|G|_{dB}$

568 .5 $\times f_o$ = (e,.5 $\times f_c$) Hz

569 .7 $\times f_o$ = (e,.7 $\times f_c$) Hz

570 1 $\times f_o$ = (e,1 $\times f_c$) Hz

571 2 $\times f_o$ = (e,2 $\times f_c$) Hz

572 3 $\times f_o$ = (e,3 $\times f_c$) Hz

573 5 $\times f_o$ = (e,5 $\times f_c$) Hz

574 10 $\times f_o$ = (e,10 $\times f_c$) Hz

575 calc n61=648

576 n61+61

577 entry v08m3l

578 calc n61+n61+1

579 calcs (n61-63), v70=-6.5,-4.7,-3,-.5,-3,8

580 arrow (n60+n60+200)

581 store -v(n61)

582 ansy v70,.3

583 crater now

584 inhibit erase

585 goto (n61>66), x08m3m, x08m3l

586 ***

587 unit x08m3m

588 next x08m3n

589 back v08m3k

590 at 2105

591 write To make evaluation of your data more meaningful,
592 the data above will be plotted when you press -NEXT-.

592 ***

593 unit x08m3n

594 back x08m3k

595 erase

596 origin 100,100

597 axes 300,300

598 lscalex 10000,10

599 scaley 0,-10

600 markx 20,10,2

601 labely 2,1,0

602 gdraw (.5 $\times f_c$),v62; (.7 $\times f_c$),v63; f_c,v64; (2 $\times f_c$),v65; (3 $\times f_c$),v66; (5 $\times f_c$),v67; (10 $\times f_c$),v68

603 write 4at,2713 $\times 10^1$ 10² Hz 10³ 10⁴

604 write 4at,1606 \times dB

605 at 205

606 write The graph below is known as a Bode plot of the
607 gain. Note that the vertical scale is a linear plot
608 of logarithmic values, and the horizontal scale is
609 a logarithmic plot of frequency values.

Note also that at low frequencies (below f_0), the gain is low, while at high frequencies, the gain is approaching unity ($0 \text{ dB} = 1$). Hence, this two port network is called a high-pass filter.

part=1, block=m

block 1m, x08m30

616 unit $\times 10^3$
617 back $\times 10^3$
618 next $\times 10^3$
619 at 485
620 write We will now measure the frequency response of the
621 voltage gain for another type of two port network.

Leave the two port network board plugged in, but
remove all connections to the board and to the

626	peach	n/ɔ:, ənənətətʃəb,ənənətətʃəb,ənənətətʃəb
627	join	ðeɪn
628	jump	n/dʒ, əməmp,əməmp
629	* *	

630 unit * >98m3p
631 back * >98m3p
632 next * >98m3p
633 lab * >98m3ch
634 zero err
635 gt :
636 write The next two port network to be studied consists
637 of terminals 4, 5, & 2 on the TWO PORT NETWORK EQUIP

The input port is between terminals 4 & 2, and the output port is between terminals 5 & 2, with the common terminal 2 used as the ground terminal.

641 Make the necessary connections to this two port to
642 enable you to measure $|S_{11}|$ as a function of frequency.

These connections shall be same as those used for the 1st & two-ports. Press -LAB- to review the necessary connections.

646 end

647. 九章本

642 tinit >08m3-q
643, pack n33,0aaibc9000000fa1fbcc000000000bacf
650 join cke
651 calc errmesat
652 errren47
653 jump n47, +08m3d, >08m3n

block in, x08m3r

655 unit x08m3r
656 back x08m3p
657 next x08m3s
658 data x08m2h
659 calc it+4
660 at ot+5
661 at 405

662 write Set the dials on the equipment to measure $|G|_{dB}$ of this two port network. Use the same dial settings that you used to measure $|G|_{dB}$ of the high pass filter.

665 Press -DATA- to review the needed dial settings.

666 ***

667 unit x08m3s
668 pack n33,++m+cfbab++++++bb (pq) h
669 join ckd
670 calc errmess#2
671 err+n47
672 jump n47, x08s2f, x08m3t
673 ***

674 unit x08m3t
675 back x08m3r
676 next x08m3u
677 lab x08m2l
678 at 405

679 write Now measure the frequency response of $|G|_{dB}$ as follows:

680 1) At 100 Hz, adjust the A.O. AMPLITUDE dial so that
681 the VTVM (which is currently displaying V_2) reads 0 dB,
682 when the RANGE dial is set to the +10 dB scale.

683 2) Now keeping V_1 constant, increase the frequency of the
684 A.O. until the gain is down 3 dB from its 100 Hz value.

685 Press -LAB- for a suggestion on keeping V_1 constant.

686 At what frequency is the gain down 3 dB? Hz.

687 arrow 1549.

688 store f_c

689 ansy 1820.3%

690 writing

691 at 1805

692 write The frequency at which $|G|_{dB}$ is down 3 dB from its
693 low frequency value is known as the corner frequency
694 f_c of this network.

block 2a, x08m3u

696 unit x08m3u
697 back x08m3t
698 lab x08m3l
699 base
700 at 400
701 write

Measure $|G|_{dB}$ of this two port as indicated below.

Press -LAB- to review the measurement procedure.

702 at 810

703 write FREQUENCY $|G|_{dB}$

705 $1 \cdot f_O = 1e. .1 \cdot f_O$ Hz

706 $2 \cdot f_O = 1e. .2 \cdot f_O$ Hz

707 $.5 \cdot f_O = 1e. .5 \cdot f_O$ Hz

708 $.7 \cdot f_O = 1e. .7 \cdot f_O$ Hz

709 $1 \cdot f_O = 1e. .1 \cdot f_O$ Hz

710 $1 \cdot f_O = 1e. .2 \cdot f_O$ Hz

711 $1 \cdot f_O = 1e. .3 \cdot f_O$ Hz

712 $1 \cdot f_O = 1e. .5 \cdot f_O$ Hz

713 $10 \cdot f_O = 1e. .10 \cdot f_O$ Hz

714 calc m00e040

715 no 1e99

716 entry x08m3v

717 calc n61en61+1

718 calcs (n61-101), v7040, -2, -1, -1.9, -3, -7.2, -10.1, -14, -20

719 arrow (n60en60+2000)

720 store v(n61)

721 ansy v70, .3

722 no

723 endarrow

724 inhibit erase

725 goto (n61>107), x08m3w, x08m3v

726 .444

727 unit x08m3w

728 back x08m3u

729 next x08m3x

730 at 2005

To make evaluation of your data more meaningful,
the data above will be plotted when you press -NEXT-.

```

734 unit x08m3x
735 back x08m3u
736 next x08m4a
737 erase
738 origin 100,100
739 axes 300,300
740 lscalex 1000000,100
741 scaley 0,-25
742 markx 20,10,2
743 labely 5,1,0
744 gdraw (.1*fo),v100; (.2*fo),v101; (.5*fo),v102; (.7*fo),v103; fo,v104
745 gdraw fo,v104; (2*fo),v105; (3*fo),v106; (5*fo),v107; (10*fo),v108
746 write {at,2713}102 103 Hz 105
747 write {at,1606}dB 105
748 at 205
749 write
750

```

The graph below is the Bode plot of $|G|_{dB}$ for the two port network you currently have set up.

```

751 Note that the plot differs from the Bode plot of the
752 high-pass filter previously studied.
753 at 2805

```

```

754 write Since low frequencies are passed and high frequencies
755 are attenuated, this two port network is known as
756 a low-pass filter.

```

----- part=2, block=b -----

block 2b, x08m4a

```

758 unit x08m4a
759 restart
760 base
761 back x08m3x
762 next x08m4b
763 erase
764 catchup
765 at 405
766 write The great utility of the Bode-plot method of
767 recording G vs f is easily demonstrated.

```

Consider the two gains you have evaluated experimentally for the high-pass and low-pass filters. The gain for a filter consisting of those two filters cascaded is simply the product of the gains of the individual filters.

The 2 two-ports are cascaded simply by connecting Terminal 3 to Terminal 4. The input port is then Terminals 1 & 2, and the output port is Terminals 5 & 2. Note that Terminal 2 is the common ground terminal.

The gain $|G|_{dB}$ of this composite filter, using your calculated values, is shown in the next display.

776 ***

```

779 unit x08m4b
780 origin 75,100
781 axes 350,300
782 indexlex 10000000,10
783 scalely 0,-25
784 markx 20,10,2
785 labely 5,1,0
786 write {at,2709}101 102 103 104 105
787 write {at,28,241}|G|dB
788 write {at,2831}f (Hz)
789 edraw (.5*fo),v62; (.7*fo),v63; fo,v64; (2*fo),v65; (3*fo),(v66+v100);
790 edraw (3*fo),(v66+v100); (5*fo),(v67+v101); (10*fo),v68
791 edraw (10*fo),v69; (.5*fo),v102; (.7*fo),v103; fo,v104; (2*fo),v105; (3*fo),v106;
792 edraw (3*fo),v106; (5*fo),v107; (10*fo),v108

```

----- part=2, block=c -----

block 2c, x08m4c

```

794 unit x08m4c
795 base
796 back x08m4a
797 data x08m3h
798 lab x08s2i
799 help x08m2l
800 calc it#1
801 calc ct#5
802 at 405

```

Check the preceding display experimentally, by measuring
and entering |G|dB in the table below:

	FREQUENCY	G dB
805	50 Hz	
806	100 Hz	
807	200 Hz	
808	500 Hz	
809	1 kHz	
810	2 kHz	
811	5 kHz	
812	10 kHz	
813	15 kHz	
814		
815 at 2808		
816 write	Press -DATA- to review the dial settings.	
817	-LAB- to review the connections.	

818 -BACK- for the terminal numbers of the two-port.
 819 -HELP- for a hint on keeping V_1 constant.
 820 calc n60#839
 821 n61#110
 822 entry x08m4d
 823 calc n61+n61+1
 824 calcs (n61-112), v70#-4.3, -1.8, -.75, -.6, -1.3, -2.8, -9.5, -15, -18.2
 825 arrow (n60+n60+200)
 826 store v(n61)
 827 ansv v70, :5
 828 no
 829 endarrow
 830 inhibit erase
 831 goto (n61>118); x08m4e, x08m4d
 832 ***
 833 unit x08m4e
 834 next x08m4f
 835 mode rewrite
 836 at 2905 \$\$ blank lines needed for rewrite
 837 write Press -NEXT- to see your experimental values
 838 superimposed as *'s on the calculated Bode plot.
 839
 840
 841 ***
 842 unit x08m4f
 843 erase
 844 origin 75,100
 845 axes 350,300
 846 lscalex 10000000,10
 847 scaley 0,-25
 848 marks 20,10,
 849 labels 5,1,0
 850 write 4(at,2709)10^1 10^2 10^3 10^4 10^5
 851 write 4(at,28,241)|G|dB
 852 write 4(at,2831)f (Hz)
 853 edraw (.5*f_o), v62; (.7*f_o), v63; f_o, v64; (2*f_o), v65; (3*f_o), (v66+v100);
 854 edraw (3*f_o), (v66+v100); (5*f_o), (v67+v101); (10*f_o), v68
 855 edraw (10*f_o), v68; (.5*f_o), v102; (.7*f_o), v103; f_o, v104
 856 edraw f_o, v104; (2*f_o), v105; (3*f_o), v106; (5*f_o), v107
 857 edraw (5*f_o), v107; (10*f_o), v108
 858 graph 50, v111,*
 859 graph 100, v112,*
 860 graph 200, v113,*
 861 graph 500, v114,*
 862 graph 1000, v115,*
 863 graph 2000, v116,*
 864 graph 5000, v117,*
 865 graph 10000, v118,*
 866 graph 15000, v119,*
 867 at 2905
 868 write Note that this two port network attenuates frequencies
 869 greater than 600 Hz and less than 200 Hz. Because of this
 870 characteristic, this network is known as a bandpass filter.
 871 pause

872 jump x08end

part=2, block=d

block 2d, x08s1a

874 unit x08s1a
875 draw 1723;1742;2342;2323;1723
876 draw 1823;1817;skip;2223;2223;2217
877 circle 3,128,160
878 circle 3,128,224
879 at 1817
880 write +
881 at 128,168
882 write -
883 at 128,188
884 write V₁
885 at 1719
886 write I₁
887 at 1819
888 write →
889 draw 1842;1848
890 circle 3,376,224
891 at 373,207
892 write +
893 draw 2242;2248
894 circle 3,376,160
895 at 375,171
896 write -
897 at 372,184
898 write V₂
899 at 348,224
900 write →
901 at 348,240
902 write I₂
903 ***

904 unit x08s1b
905 draw 1848;426,224
906 at 423,208
907 write |
908 {
909 }
910
911 draw 426,160;2248
912 at 440,188
913 write Z₁
914 ***

915 unit x08s1c
916 draw 1817;1811
917 circle 16,80,192
918 draw 1911;1811;skip;2111;2211;2217
919 at 76,192

```

920 write +
921 -
922 ***
923 unit x08s1d
924 at 200,220
925 write ~~~
926 draw 1830;1834
927 at 261,208
928 write
929
930
931 draw 2223;2242;2234;2134;skip;1834;1834;1842;skip;1826;1823
932 at 192,203
933 write 33000Ω
934 at 272,188
935 write 33000Ω
936 ***

```

937 unit x08s2a
 938 at 505

939 write Complex numbers may be written in two forms;

940 rectangular form ($A+jB$) and polar form ($|C| \angle \alpha^\circ$).

941 The two forms are interrelated by the following
 942 equations:

943 at 1010
 944 write

$$|C| = \sqrt{A^2 + B^2}$$

$$\alpha = \tan^{-1} (B/A)$$

945 at 1135

946 write $A = |C| \cos \alpha$

947 at 1605

948 write To divide two complex numbers, first put both
 949 numbers into polar form. Then divide the magnitudes
 950 and subtract the phase angles.

951 For example: $\frac{A/\alpha}{B/\beta} = \frac{A}{B} \angle (\alpha - \beta)$
 952
 953
 954 end

----- part=2, block=e -----

block 2e, x08s2b

955 unit x08s2b
 956 at 485
 957 write The network below is known as a voltage divider network,
 958 when I_2 is negligible with respect to I_1 :

```

963 at 192,380
964 write ~~~
965 R1
966 at 735
967 write I2 →
968
969 at 1034
970 write >
971 >
972 draw 820;825;skip;829;267,384;267,368;skip;267,384
973 842;skip;1220;1242;skip;267,335;267,320
974 at 280,348
975 write R2
976 at 152,346
977 write V1
978 at 320,346
979 write V2
980 at 920
981 write +
982 at 152,326
983 write -
984 at 318,327
985 write -
986 at 318,368
987 write +
988 draw 1023;1031;1131;1126;204,340;skip;204,332;200,336
989 at 1124
990 write I1
991 at 1405

```

From the above network, the following equations can be derived:

```

992 write
993 at 1626
994 write
995 write 1) V2 = R2I1.

```

```

996
997 at 2005
998 write

```

Substituting eq. 1) into eq. 2), the following equation is obtained:

$$V_2 = \frac{R_2 V_1}{R_1 + R_2}$$

The output voltage V₂ is just that part of the input voltage V₁ appearing across R₂. Hence the name 'voltage divider'.

It can be shown that this voltage divider idea holds in general for impedances Z₁ and Z₂ in place of R₁ and R₂, and also holds for ac voltages.

```

1007 end
1008 ***

```

```

1009 unit x08s2c
1010 next :: x08m2f,
1011 at 405
1012 write
1013
1014
1015 ***

```

At this point, you have not yet been asked to set any dials. Set all dials back to their initial mode positions, and then press -NEXT- to proceed.

1016 unit x08s2d
1017 help errmess, x, x08m2e, x08m3b, x08m3p
1018 next errmess, x, x08m2g, x08m3c, x08m3q
1019 join (err<0), x08s2e, x
1020 at 605

1021 write Press -NEXT- if you know and have corrected your error.

1022 or, press -HELP- to review the needed connections.
1023 ***

1024 unit x08s2e
1025 at 408
1026 write There is something wrong with your connections.

----- part=2, block=f -----

block 2f, x08s2f

1028 unit x08s2f
1029 next errmess, x, x08m2i, x08m3e, x08m3s
1030 help x08m2h
1031 join (err<0), x08s2g, x
1032 at 1085
1033 write Press -NEXT- if you know and have corrected your errors.
1034

1035 Press -HELP- if you wish to review the needed dial
1036 settings.
1037 ***

1038 unit x08s2g
1039 at 810
1040 write You have incorrectly set {2, -n47} dials(s).
1041 ***

1042 unit x08s2h
1043 at 405
1044 write Now make the following connections:

1045 1) Connect the input port of the two port network to
1046 the AUDIO OSCILLATOR.

1047 2) Also connect the input port to the A INPUT of the
1048 OSCILLOSCOPE.

1049 3) Connect the output port of the two port network
1050 to the INPUT of the VACUUM TUBE VOLTMETER.

1051 4) Finally, connect the output port of the two port
1052 network to the B INPUT of the OSCILLOSCOPE.

1053 at 2185
1054 write Did you remember to correctly connect all grounds.

1055 Press -BACK- to review the terminal numbers of the
1056 two port under study.
1057 at 2605
1058 write When you are through making the above connections,
1059 press -NEXT-.
1060 end

1061 unit x08s2i
1062 erase
1063 catchup
1064 at 405
1065 write Now make the following connections:

- 1066 1) Connect the input port of the two port network
1067 to the AUDIO OSCILLATOR.
- 1068 2) Also connect the input port to the A INPUT of the
1069 OSCILLOSCOPE.
- 1070 3) Connect the output port of the two port network
1071 to the INPUT of the VACUUM TUBE VOLTMETER.
- 1072 4) Finally, connect the output port of the two port
1073 network to the B INPUT of the OSCILLOSCOPE.
1074 at 2105
1075 write Did you remember to correctly connect all grounds.
1076 end

part=2, block=g

block 2g, x08end

1078 unit x08end
1079 back x08m3a
1080 join imode
1081 jump n47, x08end, x
1082 course n2
1083 calc n2='ee244'
1084 nc(n21+1)+(nc(n21+1)\$mask\$07777777770000000000)+046030000000,
1085 nc(n21+1)+nc(n21+1)
1086 erase
1087 output /// student has completed experiment ///
1088 join endunit
1089 join jmpomes
1090 jumpout cgeindex, questi
1091 entry leave
1092 end lesson
1093 ***
1094 unit endunit
1095 course n2
1096 jump n2='ee244', leave, x
1097 calc nc(n21+7)+nc(n21+7)+ahelp

1098 : vc(n21+6) ovc(n21+6) +atime/68888
 1099 ***Incl. oge, s.r. & terms sample, index, imode, comment, slides.
 1100 use eex00, ck1
 1101 use ck2
 1102 use ck3
 1103 use ck4
 1104 use ck5
 1105 use ck6
 ckc not found 259 419 627 658
 ckd not found 255 297 448 669
 endunit x08end 1094 28 1088
 imode not found 39 393 1088
 jmpmes not found 1089
 leave x08end 1091 1096
 x08end x08end 1078 872 1081
 x08m0a x08m0a 28 48 55
 x08m1a x08m1a 54 29 83
 x08m1b x08m1a 81 56 104
 x08m1c x08m1c 103 84 126
 x08m1d x08m1c 125 105 143
 x08m2a x08m2a 142 127 162
 x08m2b x08m2a 161 144 185
 x08m2c x08m2a 184 163 215
 x08m2d x08m2d 214 186 246 267
 x08m2e x08m2d 245 216 1017
 x08m2f x08m2d 258 247 1018
 x08m2g x08m2d 257 1018
 x08m2h x08m2d 264 262 303 427 658 1030 797
 x08m2i x08m2d 291 289 1029
 x08m2j x08m2d 295 268
 x08m2k x08m2k 302 300 337
 x08m2l x08m2k 334 304 359 677 799
 x08m2m x08m2k 342 361 448 543
 x08m2n x08m2h 358 338 397
 x08m2o x08m2n 382 360
 x08m2p x08m2n 392 394
 x08m3a x08m3a 396 394 412 425 1079
 x08m3b x08m3a 410 398 1017
 x08m3c x08m3c 417 413 1018
 x08m3d x08m3c 424 422 446
 x08m3e x08m3c 438 426 1029
 x08m3f x08m3c 445 443 478
 x08m3g x08m3c 477 447 496
 x08m3h x08m3h 495 479 514
 x08m3i x08m3h 513 497 541 698
 x08m3j x08m3i 539 515 564
 x08m3k x08m3j 563 542 588 594 617
 x08m3l x08m3j 576 584
 x08m3m x08m3j 586 584
 x08m3n x08m3j 593 587
 x08m3o x08m3o 616 628 631
 x08m3p x08m3o 630 618 628 656 1017
 x08m3q x08m3o 648 632 1018
 x08m3r x08m3r 655 653 675
 x08m3s x08m3r 667 657 1029
 x08m3t x08m3r 674 672 697
 x08m3u x08m3u 696 676 728 735

x08m3v	x08m3u	716	725					
x08m3w	x08m3u	727	725					
x08m3x	x08m3u	734	729	761				
x08m4a	x08m4a	756	736	796				
x08m4b	x08m4a	779	762					
x08m4c	x08m4c	794						
x08m4d	x08m4c	822	831					
x08m4e	x08m4c	833	831					
x08m4f	x08m4c	842	834					
x08s1a	x08s1a	874	95	149	171	197	220	
x08s1b	x08s1a	904	96	151	173			
x08s1c	x08s1a	915	97	150	172	198	229	
x08s1d	x08s1a	923	196	227				
x08s2a	x08s1a	937	164					
x08s2b	x08s2b	959	187	480				
x08s2c	x08s2b	1009	256					
x08s2d	x08s2b	1016	262	422	653			
x08s2e	x08s2b	1024	1019					
x08s2f	x08s2f	1028	308	443	672			
x08s2g	x08s2f	1038	1031					
x08s2h	x08s2f	1042	250	414	633			
x08s2i	x08s2f	1061	798					
ahelp	x08def	1097						
atime	x08def	1098						
err	x08def	31	37	249	261	269 421	299 442	411
errmess	x08def	634	652	671	1019	1031		
f0	x08def	32	248	268	298	420 670	441 1017	651
f0	x08def	1018	1029					
f0	x08def	35	555	568	569	570 573	571 602	572
f0	x08def	602	602	602	602	602 784	602 784	789
f0	x08def	789	789	790	790	790 853	791 853	853
f0	x08def	853	853	854	854	854	855	
f0	x08def	36	688	705	706	707 714	708 711	709
f0	x08def	712	713	744	744	744 745	744 745	744
f0	x08def	745	745	745	791	791 791	791 792	791
f0	x08def	792	792	855	855	855 856	856 856	
f0	x08def	857	857					
it	x08def	33	217	283	428	659	800	
nc	x08def	1084	1084	1085	1085	1097	1097	
n2	x08def	1082	1083	1095	1096			
n21	x08def	1084	1084	1085	1085	1097	1097 1098	1098
n33	x08def	254	258	296	418	439	626 668	649
n47	x08def	48	256	261	262	299 421	300 422	394
n50	x08def	442	443	628	652	653 670	671 1081	672
n51	x08def	31						
n52	x08def	32						
n53	x08def	33						
n54	x08def	34						
n55	x08def	574	579	579	714	719 825	719 825	820
n56	x08def	575	577	577	578	580 717	584 717	715
ot	x08def	718	720	725	821	823 826	823 831	824
v	x08def	34	218	286	429	660	801	
vc	x08def	580	720	826				
v100	x08def	1098	1098					
v101	x08def	744	789	798	853	854		
v102	x08def	744	798	854				
v102	x08def	744	791	855				

v183	x08def	744	791	855		
v184	x08def	744	745	791	855	856
v185	x08def	745	791	856		
v186	x08def	745	791	792	856	
v187	x08def	745	792	856	857	
v188	x08def	745	792	857		
v111	x08def	858				
v112	x08def	859				
v113	x08def	860				
v114	x08def	861				
v115	x08def	862				
v116	x08def	863				
v117	x08def	864				
v118	x08def	865				
v119	x08def	866				
v52	x08def	314	328	323	324	
v55	x08def	35				
v56	x08def	36				
v62	x08def	602	789	853		
v63	x08def	602	789	853		
v64	x08def	602	789	853		
v65	x08def	602	789	853		
v66	x08def	602	789	790	853	854
v67	x08def	602	790	854		
v68	x08def	602	790	791	854	855
v70	x08def	578	581	718	721	824
%	x08def	315	323	324	556	689

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